Outcome Based Education (OBE) Curriculum for the Undergraduate Program of the Department of Electrical and Electronic Engineering at the University of Dhaka

Prepared by:

Department of Electrical and Electronic Engineering (EEE)

University of Dhaka

Session: 2024-2025 and Onwards

Name of the University	: UNIVERSITY OF DHAKA
Name of the Faculty	: Faculty of Engineering and Technology
Name of the Department	: Department of Electrical and Electronic Engineering
Name of the Program	: Bachelor of Science in Electrical and Electronic Engineering Abbreviated as: B.Sc. Engg. in EEE

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Part A: Overview of the Program

1. Vision of the University

Create a world-class educational ecosystem that enables individuals to act as dynamic human capital and ethical leaders for a sustainable future.

2. Mission of the University

UM1	Provide transformative education by enabling students to embrace lifelong learning and fostering a sustainable knowledge-based society through the continuous pursuit of scholarship, humanistic values, and technological innovation.
UM2	Pursue collaborative research and innovation, leveraging partnerships to expand the boundaries of knowledge.
UM3	Develop an educational ecosystem that fosters excellence, transparency, inclusivity, and accountability.
UM4	Engage with stakeholders and communities to build a just, fair, diverse, and sustainable world.
UM5	Encourage students to become ethically responsible global citizens with a positive societal impact.
UM6	Instill a deep sense of national heritage and pride in students, upholding historical roots and global connectivity.

3. Vision of the Department

To develop professionally competent and socially conscious electrical and electronic engineers who are well prepared to confront challenges in both national and global environments.

4. Mission of the Department

To attain academic excellence through research, innovation, and industry collaboration, with a focus on both national and global perspectives. We achieve our mission by

M1	Capacity-building through high academic standards, fostering innovation in education, and preparing graduates for professional success in a diverse, welcoming, and inclusive environment.
M2	Generating new knowledge by facilitating a culture of research and innovation in electrical and electronic engineering, contributing to advancements with national and international significance and maintaining excellence in all programs.
M3	Enhancing educational relevance by building strong ties with alumni, industry partners, and other stakeholders, ensuring hands-on skills and addressing continuing educational needs in an accessible and affordable manner.
M4	Contributing to the community through coordinated outreach programs, knowledge transfer, and engineering solutions to address societal challenges.

5. Description of the Program

The Dept. of EEE, DU is renowned for producing visionary electrical and electronic engineers. Our state-of-the-art curriculum blends theory with hands-on experimentation, coupled with a strong emphasis on innovation, propels our graduates to the forefront of technological advancement. The department takes the pride in nurturing versatile professionals equipped to lead in academia, industry, government, and the corporate world. Additionally, our cutting-edge research initiatives enable our graduates to consistently secure admission to some of the world's most prestigious graduate schools.

6. Program Educational Objectives (PEOs)

The PEOs of the EEE undergraduate program are for graduates to achieve the following, within three to five years after graduation.

PEOs	**Attributes**
PEO1	Demonstrate professional competence in electrical and electronic engineering, applying their knowledge and skills to effectively contribute to industry, research, or academia.
PEO2	Capable of identifying and addressing challenges, driving positive change, and contributing to the advancement of technology and engineering practices.
PEO3	Able to convey technical information clearly, work effectively in teams, and engage in constructive dialogue to solve complex problems in a global context.
PEO4	Demonstrate a strong commitment to ethical practices and social responsibility in their professional activities.
PEO5	Engage in continuous professional development, staying current with emerging trends, and be prepared to embrace new challenges and opportunities throughout their careers.

7. Mapping of Mission of the University with Mission of the Department

	DU Mission 1	DU Mission 2	DU Mission 3	DU Mission 4	DU Mission 5	DU Mission 6
EEE Mission 1	✓		✓		✓	
EEE Mission 2	✓	✓				
EEE Mission 3		✓	✓	✓		
EEE Mission 4				✓	✓	✓

8. Mapping of Mission of the Department with PEOs

	EEE Mission 1	EEE Mission 2	EEE Mission 3	EEE Mission 4
PEO1	✓	✓		
PEO2	✓	✓		✓
PEO3	✓		✓	
PEO4	✓		✓	✓
PEO5		✓		✓

9. Program Outcomes (POs) with Graduate Attributes

The teaching methods employed in the department are centered on the program outcomes set by the department itself. The department adheres to the following program outcomes for its undergraduate programs.

POs	**Characteristics**	**Graduate Attributes Profile**
PO1	Engineering knowledge	Apply knowledge of mathematics, natural science, engineering fundamentals, and a specialized area within engineering to solve complex engineering problems. [*K1 to K4]
PO2	Problem analysis	Identify, formulate, research literature, and analyze complex engineering problems, arriving at well-founded conclusions through the application of first principles of mathematics, natural sciences, and engineering sciences. [*K1 to K4]
PO3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that fulfill specified requirements, giving due consideration to public health and safety, as well as cultural, societal, and environmental considerations. [*K5]
PO4	Investigation	Investigations of complex problems by employing research-based knowledge and research methods, which encompass designing experiments, analyzing and interpreting data, and synthesizing information. [*K8]
PO5	Modern tool usage	Create, select, and employ appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to address complex engineering problems, while maintaining an awareness of their inherent limitations. [*K6]
PO6	The engineer and society	Apply reasoning informed by contextual knowledge to evaluate societal, health, safety, legal, and cultural issues, along with the corresponding responsibilities inherent in professional engineering practice. [*K7]

PO7	Environment and sustainability	Understand and evaluate the sustainability and impact of professional engineering solutions for complex engineering problems within societal and environmental contexts. [*K7]
PO8	Ethics	Adhere to ethical principles and demonstrate commitment to professional ethics, responsibilities, and the norms of engineering practice. [*K7]
PO9	Individual work and teamwork	Function effectively both individually and collaboratively, serving as a valuable member or leader within diverse teams and across multidisciplinary settings.
PO10	Communication	Effectively communicate complex engineering activities to both the engineering community and society at large. This includes the ability to comprehend and produce effective reports and design documentation, deliver effective presentations, and give and receive clear instructions.
PO11	Project management and finance	Demonstrate knowledge and understanding of engineering and management principles, along with the ability to make economically sound decisions, and manage projects, in multidisciplinary environments.
PO12	Life-long learning	Acknowledge the necessity for, and possess the preparation and capability to engage in independent and lifelong learning within the broader context of technological change.

**For description of the Knowledge Profile [K1-K8], please refer to Appendix C in Page 338*

10. Mapping of PEOs with POs

	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	✓				
PO2		✓			
PO3			✓		
PO4	✓				
PO5					✓
PO6				✓	
PO7				✓	
PO8				✓	
PO9			✓		
PO10			✓		
PO11		✓			
PO12					✓

Part B: Overview of the Curriculum

11. Structure of the Curriculum

11.1 Admission Requirement:

Students are admitted in the 1st Year 1st Semester of B.Sc. in the Electrical and Electronic Engineering as per existing university rules.

11.2 Duration of the Program : 4 years

Total Number of Semesters	: 4 × 2 = 8 (2 Semesters per year)
Class	: 14 weeks
Incourse Examination	: 1 week
Preparatory Leave (PL)	: 2 weeks
Final Examination (theory)	: 3 weeks
Results	: 3 weeks
Total	: 23 weeks per semester

11.3 Total Credits in 8 semesters (4 years): 165

Year	Courses (Credits)	
Year 1	**Semester I:** Theory Courses: 5 (3×5 Credits) Lab Courses: 2 (1.5×2 Credits) **Total: 18 Credits**	**Semester II:** Theory Courses: 5 (3×5 Credits) Lab Courses: 3 (1.5×3 Credits) **Total: 19.5 Credits**
Year 2	**Semester I:** Theory Courses: 6 (3×6 Credits) Lab Courses: 2 (1.5×2 Credits) **Total: 21 Credits**	**Semester II:** Theory Courses: 5 (3×5 Credits) Lab Courses: 3 (1.5×3 Credits) **Total: 19.5 Credits**
Year 3	**Semester I:** Theory Courses: 6 (3×6 Credits) Lab Courses: 2 (1.5×2 Credits) **Total: 21 Credits**	**Semester II:** Theory Courses: 6 (3×6 Credits) Lab Courses: 3 (1.5×3 Credits) **Total: 22.5 Credits**
Year 4	**Semester I:** Theory Courses: 5 (3×5 Credits) Departmental : 1 Hum. & Soc. Science : 1 Own Stream : 2 Other Stream : 1 Lab Courses: 3 (1.5×3 Credits) Departmental : 1 Own Stream : 1 Other Stream : 1 Project: 1 (2 Credits) **Total: 21.5 Credits**	**Semester II:** Theory Courses: 5 (3×5 Credits) Departmental : 1 Interdisciplinary : 1 Own Stream : 2 Other Stream : 1 Lab Courses: 2 (1.5×2 Credits) Departmental : 1 Interdisciplinary : 1 Project: 1 (4 Credits) **Total: 22 Credits**

11.4 Total Minimum Credit Requirement:

Total credits to be completed for obtaining the degree of B.Sc. Engg. in Electrical and Electronic Engineering is 165.

11.5 Total Class Hours in 8 Semesters:

Total Contact Hours in a semester for each 1 credit theory course: 14×56 = 784 mins.

Total Contact Hours in a semester for each 1 credit lab course: 14×2 = 28 hours.

11.6 Minimum CGPA Requirement for Yearly Promotion and to Obtain a Degree: 2.00 (D)

11.7 Maximum Academic Years of Completion: 6 years

11.8 Grading System: The current University Grants Commission (UGC) approved grading system applies as per university rules.

Marks	**Letter Grade**	**Grade Point**
80% and above	A+	4.00
75% to <80%	A	3.75
70% to <75%	A-	3.50
65% to <70%	B+	3.25
60% to <65%	B	3.00
55% to <60%	B-	2.75
50% to <55%	C+	2.50
45% to <50%	C	2.25
40% to <45%	D	2.00
Less than 40%	F	0.00

11.9 Marks Distribution:

For a theory course

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

For a laboratory course

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

11.10 Attendance Policy:

75% and above	Eligible to sit for semester final exam
60% to <75%	Eligible to sit for semester final exam after paying the fines as per university rules
Less than 60%	Not eligible to sit for the final examination

Marks distribution for attendance

Attendance	**Marks**
90% and above	5.0%
85% to <90%	4.5%
80% to <85%	4.0%
75% to <80%	3.5%
70% to <75%	3.0%
65% to <70%	2.5%
60% to <65%	2.0%
Less than 60%	0.0%

11.11 Improvement Examination: A student may opt to take an improvement examination for courses in which the obtained grade is less than B (3.00). If the grade is not improved through the examination, the previous grade will remain valid. However, students can sit for improvement examinations up to two times within the two subsequent academic years.

11.12 Readmission and Dropout: A student may be granted re-admission a maximum of two times within six consecutive academic years. To be eligible for re-admission, a student must seek permission, having maintained at least 30% attendance in the previous semester.

11.13 Course Requirement for Graduation

Natural Science

Requirement: 15 Credits (12 + 3)		
Theoretical		
0533-PHY-1103	Electricity and Magnetism	3.0 Credits
0533-PHY-1201	Modern Physics	3.0 Credits
0533-PHY-1203	Optics	3.0 Credits
0531-CHE-1207	Chemistry	3.0 Credits
Laboratory		
0533-PHY-1204	Physics Laboratory	1.5 Credits
0531-CHE-1208	Chemistry Laboratory	1.5 Credits

**For details of the Course Code Policy, please refer to Appendix A in Page 337*

Mathematics

Requirement: 15 Credits		
Theoretical		
0541-MAT-1105	Differential and Integral Calculus	3.0 Credits
0541-MAT-1107	Linear Algebra and Numerical Analysis	3.0 Credits
0541-MAT-1209	Vector Calculus and Complex Analysis	3.0 Credits
0541-MAT-2111	Ordinary and Partial Differential Equations	3.0 Credits
0542-STA-2207	Probability and Statistics	3.0 Credits

Humanities and Social Science

Requirement: 12 Credits		
Theoretical		
0231-GED-1109	English for Technical Communication	3.0 Credits
0311-GED-2209	Fundamentals of Economics	3.0 Credits
0411-GED-3211	Financial Accounting and Cost Management	3.0 Credits
0223-GED-4103	Professional Ethics	3.0 Credits

Departmental Compulsory Courses

Requirement: 82.5 Credits (63 + 19.5)		
Theoretical		
0713-EEE-1101	Electrical Circuit Analysis	3.0 Credits
0714-EEE-2101	Analog Electronics I	3.0 Credits
0714-EEE-2103	Digital Electronics	3.0 Credits
0714-EEE-2105	Solid State Physics	3.0 Credits
0713-EEE-2107	Electromechanical Energy Conversion I	3.0 Credits
0714-EEE-2109	Signals and Systems	3.0 Credits
0714-EEE-2201	Analog Electronics II	3.0 Credits
0713-EEE-2203	Electromechanical Energy Conversion II	3.0 Credits
0714-EEE-3101	Electromagnetic Theory and Antenna	3.0 Credits
0714-EEE-3103	Microprocessor and Interfacing	3.0 Credits
0714-EEE-3105	Communication Systems	3.0 Credits
0714-EEE-3107	Industrial and Medical Instrumentation	3.0 Credits
0714-EEE-3109	Electronic Devices	3.0 Credits
0713-EEE-3201	Power System I	3.0 Credits
0714-EEE-3203	Digital Signal Processing	3.0 Credits

0714-EEE-3205	Materials Science	3.0 Credits
0714-EEE-3207	Optoelectronics and Photonics	3.0 Credits
0714-EEE-3209	Communication Theory	3.0 Credits
0714-EEE-4101	Power Electronics and Industrial Automation	3.0 Credits
0714-EEE-4201	Control Engineering	3.0 Credits
Laboratory		
0713-EEE-1102	Electrical Circuit Analysis Laboratory	1.5 Credits
0714-EEE-2102	Circuit Simulation Laboratory	1.5 Credits
0714-EEE-2104	Digital Electronics Laboratory	1.5 Credits
0714-EEE-2202	Analog Electronics Laboratory	1.5 Credits
0713-EEE-2204	Electromechanical Energy Conversion Laboratory	1.5 Credits
0714-EEE-3104	Microprocessor and Interfacing Laboratory	1.5 Credits
0714-EEE-3106	Communication Systems Laboratory	1.5 Credits
0713-EEE-3202	Power System I Laboratory	1.5 Credits
0714-EEE-3204	Digital Signal Processing Laboratory	1.5 Credits
0713-EEE-3214	Electrical Services Design and Drafting Laboratory	1.5 Credits
0714-EEE-4102	Power Electronics and Industrial Automation Laboratory	1.5 Credits
0714-EEE-4202	Control Engineering Laboratory	1.5 Credits
Interdisciplinary Courses		
Theoretical		
0713-EEE-4271	Renewable Energy Technology	3.0 Credits
Laboratory		
0713-EEE-4272	Renewable Energy Technology Laboratory	1.5 Credits

Departmental Optional Courses

Requirement: 21 Credits (18 + 3)		
Electronics Stream		
Theoretical		
0714-EEE-4131	Device Fabrication Techniques	3.0 Credits
0714-EEE-4133	VLSI Circuit Design	3.0 Credits
0714-EEE-4231	Quantum Mechanics	3.0 Credits
0714-EEE-4233	Nanoelectronics	3.0 Credits
0714-EEE-4235	Advanced Semiconductor Devices	3.0 Credits

Laboratory		
0714-EEE-4134	VLSI Design Laboratory	1.5 Credits
Communication Stream		
Theoretical		
0714-EEE-4141	Telecommunication Engineering	3.0 Credits
0714-EEE-4143	Optical Fiber Communication Systems and Networks	3.0 Credits
0714-EEE-4241	Mobile Cellular Communication	3.0 Credits
0714-EEE-4243	Microwave and Satellite Communication	3.0 Credits
0714-EEE-4245	Digital Image Processing	3.0 Credits
0612-CSE-4247	Network and Information Security	3.0 Credits
Laboratory		
0714-EEE-4144	Optical Fiber Communication Laboratory	1.5 Credits
Power Stream		
Theoretical		
0713-EEE-4151	Power System II	3.0 Credits
0713-EEE-4153	Power System Protection	3.0 Credits
0713-EEE-4251	Power System Operation and Control	3.0 Credits
0713-EEE-4253	Power Plant Engineering	3.0 Credits
0713-EEE-4255	High Voltage Engineering	3.0 Credits
Laboratory		
0713-EEE-4154	Power System Protection Laboratory	1.5 Credits
Computer Stream		
Theoretical		
0612-CSE-4161	Computer Organization and Architecture	3.0 Credits
0612-CSE-4163	Data and Computer Network	3.0 Credits
0613-CSE-4165	Big Data Analysis	3.0 Credits
0613-CSE-4167	Object Oriented Programming	3.0 Credits
0714-EEE-4261	Artificial Intelligence	3.0 Credits
0612-CSE-4263	Data Base Management System	3.0 Credits
0714-EEE-4265	Internet of Things	3.0 Credits
0714-EEE-4267	Neural Network and Fuzzy Systems	3.0 Credits
0714-EEE-4269	Robotics and Embedded Systems	3.0 Credits
Laboratory		

0612-CSE-4164	Data and Computer Network Laboratory	1.5 Credits

Project

Requirement: 6 Credits		
0714-EEE-4100	Project Work	2.0 Credits
0714-EEE-4200	Project Work	4.0 Credits

Non-departmental Engineering Courses

Requirement: 13.5 Credits (9 + 4.5)		
Theoretical		
0613-CSE-1205	Computer Programming	3.0 Credits
0715-MEC-2205	Fundamentals of Mechanical Engineering	3.0 Credits
0413-IPE-3111	Industrial Management	3.0 Credits
Laboratory		
0732-CIV-1112	Computer Aided Engineering Drawing	1.5 Credits
0613-CSE-1206	Computer Programming Laboratory	1.5 Credits
0715-MEC-2206	Mechanical Engineering Laboratory	1.5 Credits

Summary of the Course Requirement for Graduation

Courses	Requirements
A. Natural Science	15.0 Credits
B. Mathematics	15.0 Credits
C. Humanities and Social Sciences	12.0 Credits
D. Departmental Core Courses	82.5 Credits
E. Departmental Optional Courses	21.0 Credits
F. Non-departmental Engineering Courses	13.5 Credits
Project	6.0 Credits
Total	165 Credits

12. Scheme of the Program

12.1 Scheme of 1st Year 1st Semester

Course Code	Course Title	Credits
0713-EEE-1101	Electrical Circuit Analysis	3.0
0533-PHY-1103	Electricity and Magnetism	3.0
0541-MAT-1105	Differential and Integral Calculus	3.0
0541-MAT-1107	Linear Algebra and Numerical Analysis	3.0
0231-GED-1109	English for Technical Communication	3.0

0713-EEE-1102	Electrical Circuit Analysis Laboratory	1.5
0732-CIV-1112	Computer Aided Engineering Drawing	1.5
	Total Credits in 1st Year 1st Semester	18

12.2 Scheme of 1st Year 2nd Semester

Course Code	Course Title	Credits
0533-PHY-1201	Modern Physics	3.0
0533-PHY-1203	Optics	3.0
0613-CSE-1205	Computer Programming	3.0
0531-CHE-1207	Chemistry	3.0
0541-MAT-1209	Vector Calculus and Complex Analysis	3.0
0533-PHY-1204	Physics Laboratory	1.5
0613-CSE-1206	Computer Programming Laboratory	1.5
0531-CHE-1208	Chemistry Laboratory	1.5
	Total Credits in 1st Year 2nd Semester	19.5

12.3 Scheme of 2nd Year 1st Semester

Course Code	Course Title	Credits
0714-EEE-2101	Analog Electronics I	3.0
0714-EEE-2103	Digital Electronics	3.0
0714-EEE-2105	Solid State Physics	3.0
0713-EEE-2107	Electromechanical Energy Conversion I	3.0
0714-EEE-2109	Signals and Systems	3.0
0541-MAT-2111	Ordinary and Partial Differential Equations	3.0
0714-EEE-2102	Circuit Simulation Laboratory	1.5
0714-EEE-2104	Digital Electronics Laboratory	1.5
	Total Credits in 2nd Year 1st Semester	21

12.4 Scheme of 2nd Year 2nd Semester

Course Code	Course Title	Credits
0714-EEE-2201	Analog Electronics II	3.0
0713-EEE-2203	Electromechanical Energy Conversion II	3.0
0715-MEC-2205	Fundamentals of Mechanical Engineering	3.0
0542-STA-2207	Probability and Statistics	3.0
0311-GED-2209	Fundamentals of Economics	3.0
0714-EEE-2202	Analog Electronics Laboratory	1.5
0713-EEE-2204	Electromechanical Energy Conversion Laboratory	1.5
0715-MEC-2206	Mechanical Engineering Laboratory	1.5
	Total Credits in 2nd Year 2nd Semester	19.5

12.5 Scheme of 3^{rd} Year 1^{st} Semester

Course Code	Course Title	Credits
0714-EEE-3101	Electromagnetic Theory and Antenna	3.0
0714-EEE-3103	Microprocessor and Interfacing	3.0
0714-EEE-3105	Communication Systems	3.0
0714-EEE-3107	Industrial and Medical Instrumentation	3.0
0714-EEE-3109	Electronic Devices	3.0
0413-IPE-3111	Industrial Management	3.0
0714-EEE-3104	Microprocessor and Interfacing Laboratory	1.5
0714-EEE-3106	Communication Systems Laboratory	1.5
	Total Credits in 3^{rd} Year 1^{st} Semester	21

12.6 Scheme of 3^{rd} Year 2^{nd} Semester

Course Code	Course Title	Credits
0713-EEE-3201	Power System I	3.0
0714-EEE-3203	Digital Signal Processing	3.0
0714-EEE-3205	Materials Science	3.0
0714-EEE-3207	Optoelectronics and Photonics	3.0
0714-EEE-3209	Communication Theory	3.0
0411-GED-3211	Financial Accounting and Cost Management	3.0
0713-EEE-3202	Power System I Laboratory	1.5
0714-EEE-3204	Digital Signal Processing Laboratory	1.5
0713-EEE-3214	Electrical Services Design and Drafting Laboratory	1.5
	Total Credits in 3^{rd} Year 2^{nd} Semester	22.5

12.7 Scheme of 4^{th} Year 1^{st} Semester

Course Code	Course Title	Credits	Comments
0714-EEE-4101	Power Electronics and Industrial Automation	3.0	Compulsory for all streams (Departmental)
0714-EEE-4102	Power Electronics and Industrial Automation Laboratory	1.5	
0223-GED-4103	Professional Ethics	3.0	Compulsory for all streams (Humanities and Social Science)
*OA1B-FFF-41ST	Optional I (theory)	3.0	Select from own stream of departmental optional courses
*OA1B-FFF-41ST	Optional II (theory)	3.0	
*OA1B-FFF-41ST	Optional II (laboratory)	1.5	
*OA1B-FFF-41ST	Optional III (theory)	3.0	

*OA1B-FFF-41ST	Optional III (laboratory)	1.5	Select from any other stream of departmental optional courses
0714-EEE-4100	Project Work	2.0	Compulsory for all streams
Total Credits in 4th Year 1st Semester		21.5	

*A = 6–7; B = 2–4; FFF = EEE or CSE; S = 3–6; T = 1–9

12.8 Scheme of 4th Year 2nd Semester

Course Code	Course Title	Credits	Comments
0714-EEE-4201	Control Engineering	3.0	Compulsory for all streams (Departmental)
0714-EEE-4202	Control Engineering Laboratory	1.5	
0713-EEE-4271	Renewable Energy Technology	3.0	Compulsory for all streams (Interdisciplinary)
0713-EEE-4272	Renewable Energy Technology Laboratory	1.5	
*OA1B-FFF-42ST	Optional I (theory)	3.0	Select from own stream of departmental optional courses
*OA1B-FFF-42ST	Optional II (theory)	3.0	
*OA1B-FFF-42SD	Optional III (theory)	3.0	Select from any other stream of departmental optional courses
0714-EEE-4200	Project Work	4.0	Compulsory for all streams
Total Credits in 4th Year 2nd Semester		22	

N.B. Students will choose their stream according to their interest and future plan. Number of streams offered finally may vary depending on the availability of faculties and the number of students enrolled.

13. Mapping of POs with COs of All Offered Courses

13.1 Mapping of POs with COs of All Compulsory Courses

Year & Semester	Courses	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
1st Year 1st Semester	0713-EEE-1101	✓	✓	✓									
	0533-PHY-1103	✓	✓	✓	✓	✓							
	0541-MAT-1105	✓	✓		✓								
	0541-MAT-1107	✓	✓	✓	✓								
	0231-GED-1109									✓	✓	✓	✓
	0713-EEE-1102	✓	✓	✓	✓								
	0732-CIV-1112	✓	✓	✓		✓							
1st Year 2nd Semester	0533-PHY-1201	✓	✓		✓								✓
	0533-PHY-1203	✓	✓	✓									
	0613-CSE-1205	✓	✓	✓	✓	✓				✓			

	0531-CHE-1207	✓	✓	✓		✓							
	0541-MAT-1209	✓	✓		✓	✓							✓
	0533-PHY-1204	✓	✓		✓	✓					✓		✓
	0613-CSE-1206	✓	✓	✓	✓	✓				✓	✓	✓	✓
	0531-CHE-1208	✓	✓	✓	✓	✓							
2nd Year 1st Semester	0714-EEE-2101	✓	✓										
	0714-EEE-2103	✓	✓	✓		✓							
	0714-EEE-2105	✓	✓	✓	✓	✓		✓					
	0713-EEE-2107	✓	✓	✓	✓								
	0714-EEE-2109	✓	✓	✓	✓								
	0541-MAT-2111	✓	✓	✓	✓	✓							
	0714-EEE-2102	✓	✓	✓		✓				✓			
	0714-EEE-2104	✓	✓			✓			✓	✓	✓		✓
2nd Year 2nd Semester	0714-EEE-2201	✓	✓	✓	✓								
	0713-EEE-2203	✓	✓	✓	✓								
	0715-MEC-2205	✓	✓	✓	✓	✓							
	0542-STA-2207	✓	✓	✓	✓	✓							
	0311-GED-2209		✓		✓			✓				✓	✓
	0714-EEE-2202	✓	✓	✓	✓								
	0713-EEE-2204	✓	✓	✓	✓								
	0715-MEC-2206	✓	✓	✓						✓	✓		
3rd Year 1st Semester	0714-EEE-3101	✓	✓	✓		✓				✓			
	0714-EEE-3103	✓	✓	✓									
	0714-EEE-3105	✓	✓	✓									
	0714-EEE-3107	✓	✓	✓	✓	✓							
	0714-EEE-3109	✓	✓	✓	✓	✓							
	0413-IPE-3111		✓	✓						✓		✓	
	0714-EEE-3104		✓								✓	✓	
	0714-EEE-3106	✓	✓	✓	✓	✓							
3rd Year 2nd Semester	0713-EEE-3201	✓	✓	✓	✓	✓							
	0714-EEE-3203	✓	✓	✓	✓	✓				✓			
	0714-EEE-3205	✓	✓		✓								
	0714-EEE-3207	✓	✓		✓			✓					
	0714-EEE-3209	✓	✓	✓									
	0411-GED-3211	✓	✓	✓	✓	✓					✓	✓	✓
	0713-EEE-3202	✓	✓	✓	✓	✓						✓	
	0714-EEE-3204	✓	✓	✓	✓	✓				✓	✓		✓
	0713-EEE-3214	✓	✓	✓			✓						
4th Year 1st Semester	0714-EEE-4101	✓	✓	✓	✓			✓				✓	
	0223-GED-4103	✓								✓	✓		
	0714-EEE-4102		✓	✓							✓	✓	
	0714-EEE-4100		✓				✓		✓	✓	✓	✓	
4th Year 2nd Semester	0714-EEE-4201	✓	✓	✓									
	0713-EEE-4271	✓	✓	✓	✓	✓		✓					✓
	0714-EEE-4202	✓	✓	✓									
	0713-EEE-4272	✓	✓	✓	✓	✓		✓					✓
	0714-EEE-4200	✓			✓		✓		✓	✓	✓	✓	
Summary (Compulsory)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

13.2 Mapping of POs with COs of All Optional Courses

Year & Semester	Courses	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
4th Year 1st Semester	0714-EEE-4131	✓	✓	✓									✓
	0714-EEE-4133	✓	✓	✓	✓	✓			✓				
	0714-EEE-4134	✓		✓		✓				✓			
	0714-EEE-4141	✓	✓	✓	✓	✓	✓	✓					
	0714-EEE-4143	✓	✓	✓	✓	✓				✓			
	0714-EEE-4144	✓	✓	✓	✓	✓				✓	✓		✓
	0713-EEE-4151	✓	✓	✓	✓	✓							
	0713-EEE-4153	✓	✓	✓		✓	✓						
	0713-EEE-4154		✓			✓							
	0612-CSE-4161	✓		✓		✓							
	0612-CSE-4163	✓	✓	✓	✓								
	0612-CSE-4164	✓	✓	✓	✓	✓	✓						
4th Year 2nd Semester	0714-EEE-4231	✓	✓	✓	✓	✓							✓
	0714-EEE-4233	✓	✓		✓								
	0714-EEE-4241	✓	✓	✓	✓	✓		✓					
	0714-EEE-4243	✓	✓	✓	✓	✓		✓					
	0713-EEE-4251	✓	✓	✓	✓	✓							
	0713-EEE-4253	✓	✓	✓		✓	✓	✓				✓	✓
	0714-EEE-4261	✓	✓	✓	✓	✓							
	0612-CSE-4263	✓	✓	✓		✓							

Part C: Detailed Description of Courses with Mapping of Outcomes

[*Changes in Part C can be made with the approval of the Academic Committee of the Department, except for Section 14.i.3 Course Content which is approved by the Academic Council of DU. However, these changes must not conflict with the content of Part A, Part B, or the rules and regulations of the Faculty of Engineering and Technology and the University of Dhaka. Additionally, any changes must be reflected in Section 13 of Part B*]

14. Description of all Courses of the Program

14.1 Electrical Circuit Analysis

14.1.1 Introduction of the Course

Course Code and Title: 0713-EEE-1101: Electrical Circuit Analysis.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course:

Modern civilization is completely dependent on technology and technology is highly dependent on electricity. So, knowing electricity and its effective use is very important for us. It is important to analyze the basic laws and theorems of electricity before using it and it will help us a lot in future expansion. Research or improvement on these concepts is not possible without the circuit knowledge. The main objective of this course is to provide comprehensive knowledge about DC and AC electricity and their proper usage, various theories and their applications. The course aims to develop students' skills for analysing of AC circuits.

Prerequisites (if any): 0533-PHY-1103: Electricity and Magnetism.

14.1.2 Course Objectives

The students are expected to

1) Know about DC and AC electricity.

2) Know the laws and theorems of electricity.

3) Analyze DC and AC circuits and find their response.

14.1.3 Course Content

Basic Concepts of Electrical Circuits: Charge, Current, Voltage, Power, DC Voltage and DC Current Sources, Sinusoidal AC Voltage Characteristics and Definition, Phase Relation, Average Value, Effective (rms) Values, Different AC Waveforms- Square, Triangular, Rectangular and Sawtooth.

The Basic Electrical Circuit Elements: Response of Basic R, L, and C Elements to DC and a Sinusoidal Voltage or Current, Admittance, Susceptance, Reactance and Impedance of R, L, and C Elements, Frequency Response of the Basic Elements, Average Power and Power Factor, Phasor.

Methods of Circuit Analysis (DC & AC): Ohm's Law, Nodes, Branches, Loops, Kirchhoff's Laws, Independent versus Dependent Sources, Source Conversions, Mesh Analysis, The Supermesh, Nodal Analysis, The Supernode, Delta-Wye Conversion.

Network Theorems (DC & AC): Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem, Millman's Theorem, Substitution Theorem, Reciprocity Theorem.

RC, RL and RLC Circuits: Source Free and Unit Step Transient Responses of RC and RL Circuits, RC and RL High-Pass, Low-Pass Filters, Band-pass and Band-Stop Filters, Source Free and Unit Step Transient Responses in RLC Circuit-different Damping Characteristics, Series and Parallel RLC Resonances.

AC Power and Polyphase Circuits: Instantaneous Power, Average Power, Effective Values of Current and Voltage, Apparent Power, Power Factor and Complex Power, Polyphase Systems, Single-Phase Three-Wire Systems, Three-Phase Y-Y Connection, The Delta Connection Power Measurement in Three-Phase Systems.

Non-Sinusoidal Circuit Analysis: Circuit with Non-Sinusoidal Excitations, Power and Power Factor of AC Circuits with Multiple Sources of Different Frequencies.

14.1.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Memorize/ recognize/ understand DC and AC electricity and the related laws and theorems	PO1	C1, C2	Lectures Discussions Handouts	Assignment Incourse Final Exam
CO2	Analyze/examine DC and AC electrical circuits consisting of linear electrical components R, L, and C	PO2	C3	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO3	Design/develop efficient circuits to optimize the performance and reduce the losses	PO3	C4	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO4	Apply the knowledge in solving electrical problems in homes and industries	PO3	C6	Discussions Problem-solving	Assignment Presentation Final Exam

14.1.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓

14.1.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1, 2	1-4	Charge, Current, Voltage, Power, DC Voltage and DC Current Sources, Sinusoidal AC Voltage Characteristics and Definition, Phase Relation, Average Value, Effective (rms) Values, Different AC Waveforms- Square, Triangular, Rectangular and Sawtooth.	CO1
3-4	5-8	Response of Basic R, L, and C Elementsto DC and a Sinusoidal Voltage or Current, Admittance, Susceptance, Reactance and Impedance of R, L, and C Elements, Frequency Response of the Basic Elements, Average Power and Power Factor, Phasor.	CO2 CO3
5-6	9-12	Ohm's Law, Nodes, Branches, Loops, Kirchhoff's Laws, Independent versus Dependent Sources, Source Conversions, Mesh Analysis, The Supermesh, Nodal Analysis, The Supernode, Delta-Wye Conversion.	CO1 CO2
7-8	13-16	Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem, Millman's Theorem, Substitution Theorem, Reciprocity Theorem.	CO1 CO2
9-11	17-22	Source Free and Unit Step Transient Responses of RC and RL Circuits, RC and RL High-Pass, Low-Pass Filters, Band-pass and Band-Stop Filters, Source Free and Unit Step Transient Responses in RLC Circuit-different Damping Characteristics, Series and Parallel RLC Resonances.	CO4
12-13	23-26	Instantaneous Power, Average Power, Effective Values of Current and Voltage, Apparent Power, Power Factor and Complex Power, Polyphase Systems, Single-Phase Three-Wire Systems, Three-Phase Y-Y Connection, The Delta Connection Power Measurement in Three-Phase Systems.	CO1 CO2 CO3
14	27-28	Circuit with Non-Sinusoidal Excitations, Power and Power Factor of AC Circuits with Multiple Sources of Different Frequencies.	CO1 CO2

14.1.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Will be given in convenient time. There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be minimum 1 incourse exam; if two or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final Exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.1.8 Text Books and Reference Books

1) Fundamentals of Electric Circuits, 5th Edition, Charles Alexander and Matthew Sadiku, McGraw-Hill Education.

2) Introductory Circuit Analysis, 13th Edition, Robert L. Boylestad, Pearson Education.

3) Engineering Circuit Analysis, 9th Edition, William H. Haytand Jack Kemmerly, McGraw-Hill Education.

4) Electronics and Circuit Analysis Using MATLAB, 2nd Edition, John O. Attia, CRC Press.

14.2 Electricity and Magnetism

14.2.1 Introduction of the Course

Course Code and Title: 0533-PHY-1103: Electricity and Magnetism.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students with a foundational understanding of the principles and phenomena governing electrical and magnetic fields. By delving into topics ranging from electric charge conservation to magnetic fields and electromagnetic induction, students acquire the essential knowledge necessary for comprehending and solving complex engineering problems. Through a combination of theoretical understanding and practical applications, students develop the ability to analyze, design, and implement solutions in electrical and magnetic systems.

Prerequisites (if any): No prerequisite.

14.2.2 Course Objectives

The students are expected to

1) Develop a solid foundational understanding of the principles governing electrical and magnetic fields.

2) Acquire essential knowledge necessary for solving complex engineering problems related to electricity and magnetism.

3) Develop the ability to analyze, design, and implement solutions in electrical and magnetic systems.

4) Enhance skills to calculate electric and magnetic fields, potentials, and energies, as well as to analyze the behavior of charged particles in various configurations.

14.2.3 Course Content

Electric Charges and Fields: Electric Charge, Conservation of Charge, Quantization of

Charge, Coulomb's Law, Energy of a System of Charges, Electrical Energy in a Crystal Lattice, The Electric Field, Charge Distributions, Flux, Gauss's Law, Field of a Spherical Charge Distribution, Field of a Line Charge, Field of an Infinite Flat Sheet of Charge.

Electric Potential: Electric Potential and Electric Potential Energy, Equipotential Surfaces, Calculating the Potential from the Field, Potential Due to a Charged Particle, Potential Due a Group of Charged Particles, Potential Due to an Electric Dipole, Potential Due to a Continuous Charge Distribution, Calculating the Field from the Potential, Electric Potential Energy of a System of Charged Particles.

Electric Fields Around the Conductors: Conductors in the Electrostatic Field, The General Electrostatic Problem and the Uniqueness Theorem, Image Charges, Capacitance and Capacitors, Calculating the Capacitance, Capacitors in Parallel and Series, Energy Stored in an Electric Field, Capacitor with Dielectrics and Gauss's Law.

Magnetic Fields: What Produces a Magnetic Field, Vector potential, Crossed Fields: Discovery of the Electron, Crossed Fields: The Hall Effect, A Circulating Charged, Cyclotrons and Synchrotrons, Magnetic Force on a Current-Carrying Wire, Torque on a Current Loop, The Magnetic Dipole Moment.

Magnetic Fields Due to Currents: Calculating the Magnetic Field Due to a Current, Force between Two Parallel Currents, Biot-Savart Law, Ampere's Law, Solenoids and Toroids, Magnetic Dipole.

Electromagnetic Induction: Induction and Inductance, Faraday's Law of Induction, Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductance, Self-Induction, Energy Stored in a Magnetic Field, Energy Density of a Magnetic Field, Mutual Induction.

14.2.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a comprehensive understanding of the fundamental principles governing electrical and magnetic fields	PO1	C2, A1	Lectures Handouts Discussions	Incourse Presentation Final Exam
CO2	Exhibit ability to apply acquired knowledge to solve complex engineering problems related to electricity and magnetism	PO2, PO3	C3, C4, A2	Lectures Handouts Exercise	Incourse Assignment Final Exam
CO3	Develop capability to	PO3	C3, C5, A2, A3	Lectures Handouts	Assignment Final Exam

	analyze, design, and implement solutions in electrical and magnetic systems			Discussions	
CO4	Enhance skills in calculating electric and magnetic fields, potentials, and energies, as well as analyzing the behavior of charged particles in diverse configurations	PO4, PO5	C3, C4, A2	Lectures Handouts Exercise Discussions	Incourse Presentation Final Exam

14.2.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓		✓				✓	✓								✓		✓

14.2.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Electric Charge, Conservation of Charge, Quantization of Charge Coulomb's Law, Energy of a System of Charges	CO1
2-3	3-6	Electrical Energy in a Crystal Lattice, The Electric Field, Charge Distributions, Flux, Gauss's Law Field of a Spherical Charge Distribution, Field of a Line Charge, Field of an Infinite Flat Sheet of Charge	CO1
4	7-8	Electric Potential, Electric Potential Energy Equipotential Surfaces, Calculating the Potential from the Field	CO2
5	9-10	Potential Due to a Charged Particle, Potential Due to a Group of Charged Particles, Potential Due to an Electric Dipole, Continuous Charge Distribution	CO2
6	11-12	Calculating the Field from the Potential, Electric Potential Energy of a System of Charged Particles Conductors in the Electrostatic Field, The General Electrostatic Problem	CO2
7-8	13-16	Uniqueness Theorem, Image Charges, Capacitance and Capacitors, Calculating the Capacitance	CO3

		Capacitors in Parallel and Series, Energy Stored in an Electric Field, Capacitor with Dielectrics, Gauss's Law	
9-10	17-20	Introduction to Magnetic Fields: What Produces a Magnetic Field, Vector Potential, Crossed Fields: Discovery of the Electron Crossed Fields: The Hall Effect, A Circulating Charged Particle, Cyclotrons and Synchrotrons, Magnetic Force on a Current-Carrying Wire	CO3
11	21-22	Torque on a Current Loop, The Magnetic Dipole Moment Magnetic Fields Due to Currents: Calculating the Magnetic Field Due to a Current	CO4
12-13	23-26	Force Between Two Parallel Currents, Biot-Savart Law, Ampere's Law, Solenoids and Toroids Magnetic Dipole, Induction and Inductance, Faraday's Law of Induction, Lenz's Law	CO4
14	27-28	Induction and Energy Transfers, Induced Electric Fields Inductors and Inductance, Self-Induction, Mutual Induction	CO4

14.2.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.2.8 Text Books and Reference Books

1) Electricity and Magnetism, 3rd Edition, Edward M. Purcell and David J. Morin, Cambridge University Press.

2) Fundamentals of Physics, Volume 2, 10th Edition, David Halliday, Robert Resnick and Jearl Walker, Wiley.

3) University Physics with Modern Physics, 15th Edition, Hugh D. Young and Roger A. Freedman, Pearson.

4) Fundamentals of Physics II, R. Shankar, Yale University Press.

5) Physics for Scientists and Engineers, 9th Edition, Raymond A. Serway and John W. Jewett, Cengage Learning.

6) Physics for Scientists & Engineers with Modern Physics, 4th Edition, Douglas C. Giancoli, Pearson.

14.3 Differential and Integral Calculus

14.3.1 Introduction of the Course

Course Code and Title: 0541-MAT-1105 Differential and Integral Calculus.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students in the Electrical and Electronics Engineering (EEE) department essential mathematical tools and concepts that are integral to the understanding and application of advanced engineering topics. Mastery of functions, limits, continuity, differential and integral calculus, and their applications forms the foundation for analyzing and solving complex engineering problems. By exploring these concepts, students will develop critical thinking and problem-solving skills that are crucial for designing and optimizing electrical systems, signals, and devices.

Prerequisites (if any): No prerequisite.

14.3.2 Course Objectives

The students are expected to

1) Define and work with different types of functions, evaluate their limits and analyze their continuity.

2) Perform linear approximations, and understand and compute differentials and partial derivatives.

3) Work with infinite series and applications of differential calculus.

4) Differentiate under the integral sign, evaluate multiple integrals, and understand their transformations.

5) Evaluate different types of improper integrals and work with special functions such as Fourier integrals, Gamma and Beta functions, Dirichlet integrals, Stirling's approximations, and Bessel functions.

14.3.3 Course Content

Functions, Limits and Continuity: Concept of Function, domain, Co-domain, range, One-one and Onto Functions, Finding the Inverse of a Function, Odd and Even Symmetric Functions, Polynomial, Algebraic and Transcendental Functions, The Existence of Limits, Asymptotic Behaviour of Function at Different Indeterminate Limits, Concepts of Continuity for Different Types of Functions.

Ordinary Differential Calculus: Local Linear Approximation, Differentials, L'Hôpital's Rule, Indeterminate Forms, Successive Differentiation of Single Variable and Leibnitz Theorem.

Partial Differential Calculus: Functions of Two or More Variables, Partial Derivatives, Higher Order Partial Derivatives, Theorems on Differentials, Differentiation of

Composite Functions, Euler's Theorem on Homogeneous Function, Implicit Functions, Jacobians, Partial Derivatives using Jacobians.

Infinite Series: Test of Convergence, Taylor's and Maclaurin's Expansion of Functions of a Single Variable.

Applications of Differential Calculus: Extrema of Functions, Increase, Decrease, and Concavity of Function, Rational Functions, Cusps, and Vertical Tangents.

Integral Calculus: Differentiation under the Integral Sign, Leibnitz Rule.

Multiple Integral: Evaluation of Double and Triple Integrals, Transformations of Multiple Integrals, Differential Elements of Area and Volume in Cylindrical and Spherical Coordinates.

Improper Integrals and Special Function: Improper Integrals of Different Kinds, Fourier Integral, Gamma and Beta Functions, Dirichlet Integrals, Stirlings Approximations, Bessel Function.

14.3.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Analyze and work with various functions, limits, and continuity	PO2	C4	Lectures Discussions Handouts Exercise	In-course Final Exam
CO2	Apply concepts of differential calculus	PO1, PO2	C3	Lectures Discussions Exercise	Assignment Final Exam
CO3	Utilize infinite series and integral calculus	PO1, PO2	C3	Lectures Discussions Exercise	Assignment Final Exam
CO4	Evaluate improper integrals and apply special functions	PO2, PO4	C3, C6	Lectures Discussions Exercise	Final Exam

14.3.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
	✓	✓	✓					✓		✓	✓						✓	✓	✓

14.3.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Functions, Concept of Function.	CO1
2-3	3-6	Domain, Co-domain, range, One-one and Onto Functions, Finding the Inverse of a Function, Odd and Even Symmetric Functions, Polynomial, Algebraic and Transcendental Functions. The Existence of Limits, Asymptotic Behaviour of Function at Different Indeterminate Limits, Concepts of Continuity for Different Types of Functions.	CO1
4	7-8	Local Linear Approximation, Differentials, L'Hôpital's Rule, Indeterminate Forms.	CO2
5-6	9-12	Extrema of Functions, Increase, Decrease, and Concavity of Function, Rational Functions, Cusps, and Vertical Tangents.	CO2
7	13-14	Successive Differentiation of Single Variable and Leibnitz Theorem, Functions of Two or More Variables, Partial Derivatives.	CO2
8-10	15-20	Higher Order Partial Derivatives, Theorems on Differentials, Differentiation of Composite Functions, Euler's Theorem on Homogeneous Function, Implicit Functions, Jacobians, Partial Derivatives using Jacobians.	CO2
11	21-22	Test of Convergence, Taylor's and Maclaurin's Expansion of Functions of a Single Variable.	CO3
12	23-24	Differentiation under the Integral Sign, Leibnitz Rule. Evaluation of Double and Triple Integrals, Transformations of Multiple Integrals	CO3
13	25-26	Differential Elements of Area and Volume in Cylindrical and Spherical Coordinates.	CO3
14	27-28	Improper Integrals of Different Kinds, Fourier Integral, Gamma and Beta Functions, Dirichlet Integrals, Stirlings Approximations, Bessel Function.	CO4

14.3.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) In-course: There will be a minimum 1 in-course exam; if 2 or more in-course exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%

Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.3.8 Text Books and Reference Books

1) Calculus, 11th Edition, Howard Anton, Irl C. Bivens, Stephen Davis, Wiley.

2) Calculus, 5th Edition, Earl W. Swokowski, Cengage Learning.

3) Schaum's Outlines of Advanced Calculus, 3rd Edition, Robert C Wrede and Murray R Spiegel, McGraw-Hill Education.

4) Calculus, 3rd Edition, Gilbert Strang, Wellesley-Cambridge Press.

5) Schaum's Outline of Calculus, 6th Edition, Ayres Jr., Frank and, Elliott Mendelson, McGraw-Hill Education.

6) Schaum's 3,000 Solved Problems in Calculus, 1st Edition, Elliott Mendelson, McGraw-Hill Education.

14.4 Linear Algebra and Numerical Analysis

14.4.1 Introduction of the Course

Course Code and Title: 0541-MAT-1107: Linear Algebra and Numerical Analysis.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to equip students in the EEE department with a strong foundation in both linear algebra and numerical methods, which are essential for analyzing and solving complex engineering problems. Linear algebra provides the necessary tools for understanding and manipulating vector spaces and matrix operations, which are crucial in various applications such as control systems, signal processing, and circuit analysis. Numerical analysis offers practical techniques for approximating solutions to mathematical problems that cannot be solved analytically, enabling students to develop efficient algorithms for simulations, optimizations, and real-world problem-solving in engineering contexts.

Prerequisites (if any): No prerequisite.

14.4.2 Course Objectives

The students are expected to

1) Learn and apply serval methods and matrix operations to solve systems of linear equations.

2) Explore concepts of vector spaces and subspaces, and determine linear independence, coordinates, basis, and fundamental matrix spaces.

3) Compute eigenvalues and eigenvectors and understand their significance, and perform matrix diagonalization.

4) Utilize different methods and matrix decomposition techniques for matrix factorization and analysis.

5) Implement numerical methods to solve equations in one variable and understand their convergence properties.

6) Use different numerical techniques to compute for differentiation, integration, and differential equations.

14.4.3 Course Content

Linear Algebra

Systems of Linear Equations, Matrices and Determinants: Introduction to Systems of Linear Equations, Gaussian Elimination, Gauss-Jordan Elimination, Matrices and Matrix Operations, Methods of Finding Inverse of Matrix, Diagonal, Triangular, and Symmetric Matrices, Determinants by Cofactor Expansion, Evaluating Determinants by Row Reduction, Properties of Determinants, Cramer's Rule.

Vector Space and Subspaces: Vector in Different Dimensions, Concept of Vector space, Subspace, Norm, Dot Product, and Distance, Orthogonality, Linear Independence Coordinates and Basis, Row Space, Column Space, and Null Space, Rank, Nullity, and the Fundamental Matrix Spaces.

Eigenvalues, Eigenvectors and Matrix Diagonalization: Eigenvalues and Eigenvectors, Matrix Diagonalization, Orthogonal Matrices, Orthogonal Matrix Diagonalization, Hermitian, Unitary, and Normal Matrices.

Matrix Decomposition: Gram–Schmidt Process, QR-Decomposition and Basic Concept of Singular Value Decomposition.

Numerical Analysis

Solutions of Equations in One Variable: The Bisection Method, Fixed-Point Iteration, Newton's Method and its Extensions and the Concept of Convergence.

Interpolation and Polynomial Approximation: Interpolation and the Lagrange Polynomial, Divided Difference Methods, Hermite Interpolation, Cubic Spline Interpolation.

Numerical Differentiation and Integration: Numerical Differentiation using Forward and Backward Difference Formula, The Trapezoidal Rule, Simpson's Rule, Romberg Integration.

Numerical Techniques to Differential Equations: Euler's Method, Runge-Kutta Methods, Finite Difference Method.

14.4.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Solve systems of linear equations using various matrix operations and techniques	PO1, PO2	C3	Lectures Discussions Handouts Exercise	Incourse Final Exam

CO2	Analyze vector spaces and subspaces, determine linear independence, coordinates and basis, and compute fundamental matrix spaces	PO1, PO2, PO3	C4	Lectures Discussions Exercise	Incourse Assignment Final Exam
CO3	Compute eigenvalues and eigenvectors, perform matrix diagonalization, and apply matrix decomposition techniques	PO1, PO2, PO3	C5	Lectures Discussions Exercise	Incourse Assignment Final Exam
CO4	Apply numerical techniques to solve equations, and perform numerical differentiation and integration	PO1, PO2, PO4	C4	Lectures Discussions Exercise	Incourse Final Exam

14.4.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓			✓	✓		✓		✓			✓	✓	✓		

14.4.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to linear systems, Consistent and inconsistent systems, Row reduced form and its properties	CO1
2	3-4	Gaussian Elimination, Gauss-Jordan Elimination and its application in different real life and engineering problems	CO1
3-4	5-8	Elementary matrices, Matrix multiplication, Invertible matrices, Methods of Finding Inverse of Matrix, Determinants by Cofactor Expansion, Properties of Determinants, Cramer's Rule	CO1

5-6	9-12	Introduction to vector spaces and subspace, Spanning sets, Dependence of vectors, Basis and dimensions, Rank-nullity dimension theorem,	CO2
7	13-14	Eigenvalues and Eigenvectors of Matrix, Diagonalization, The Cayley-Hamilton Theorem,	CO3
8	15-16	Matrix Decomposition: Gram–Schmidt Process, QR-Decomposition	CO3
9-10	17-20	Numerical solution of algebraic and transcendental equations: bisection method, Fixed point method, Newton-Raphson method and rate of convergence	CO4
11-12	21 -24	Newton polynomial interpolations, Divided Difference Methods Lagrange and Hermite interpolations	CO4
13	25-26	Numerical differentiation based on interpolation, Numerical Integration: Trapezoidal and Simpson's Rule, Romberg Integration.	CO4
14	27-28	Numerical solutions of ODE's using Euler's Method, Runge-Kutta Methods, Finite Difference Method	CO4

14.4.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.4.8 Text Books and Reference Books

1) Elementary Linear Algebra, 11th Edition, Howard Anton, Chris Rores, Wiley.

2) Introduction to Linear Algebra, 5th Edition, Gilbert Strang, Wellesley - Cambridge Press.

3) Linear Algebra, Elizabeth S. Meckes, Mark W. Meckes, Cambridge University Press.

4) Numerical Analysis, 10th Edition, Richard L. Burden, J. Douglas Faires, Annette M. Burden, Cengage Learning.

5) An Introduction to Numerical Analysis, Endre Süli, Cambridge University Press.

14.5 English for Technical Communication

14.5.1 Introduction of the Course

Course Code and Title: 0231-GED-1109: English for Technical Communication.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to equip students with the essential language skills required for effective communication in the field of engineering and technology. As English is the global lingua franca of science and technology, proficiency in this language is crucial for accessing technical literature, collaborating with international peers, and presenting ideas clearly and persuasively. This course addresses the critical aspects of grammar, rhetoric, writing, reading, and speaking, tailored to meet the specific needs of technical communication. By fostering these skills, students will be better prepared to articulate complex technical concepts, produce well-structured reports, engage in meaningful dialogues, and enhance their overall professional communication competence.

Prerequisites (if any): No prerequisite.

14.5.2 Course Objectives

The students are expected to

1) Develop a strong foundation in English grammar and sentence construction, enabling them to avoid common grammatical errors and improve their overall writing accuracy.

2) Acquire effective writing skills for various forms of technical communication, including paragraph writing, composition, letter and email writing, and report writing.

3) Enhance their reading, listening, and speaking abilities through targeted strategies and practice, facilitating better comprehension, presentation, and interaction in professional settings.

14.5.3 Course Content

Introduction: Global Position of English as a Language, Necessity of Learning a Second Language, English as a Language of Science and Technology Communication.

Grammar: Tense, Preposition, Subject Verb Agreement, Construction of Sentences, Transformation of Sentences: Active and Passive Transformation. Reported Speech, Grammatical Error, Conditionals.

Rhetoric: Introduction to Rhetoric, Rhetoric for Technical Communication and Persuasive Writing.

Developing Writing Skills: Principles of Effective Writing, Pre-Writing and Writing Process.

Paragraph Writing: Linking Sentences to Form a Paragraph, Paragraph Structure, Paragraph Unity and Coherence, Classification of Paragraphs.

Composition Writing: Short Composition.

Letter and E-Mail Writing: Formal and Informal, Precise Writing, Following Netiquette in E-mail Writing.

Report Writing: Defining a Report, Classification of Reports, Structure of a Report and Writing Reports.

Developing Reading Skills: Strategies of Reading: Skimming, Scanning, Inferencing, Analyzing and Interpreting Variety of Texts and Text Types.

Vocabulary Building and Phonetics: Correct and Precise Diction, Idiomatic Expressions.

English Phonetics: Vowels, Consonants and Diphthongs, Phonetic Transcription.

Developing Listening Skills: Practicing Listening by using Audio Visual Aids.

Developing Speaking Skills: Practicing Situational Dialogues; Role Play, Narrating Stories Debates, Interview Sessions, Extempore Speech, Effective Oral Presentation.

14.5.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Apply fundamental English grammar rules to produce grammatically correct and coherent sentences.	P10, P12	C3, A2	Lectures Discussions Handouts Exercise	Incourse Final Exam
CO2	Develop proficiency in writing various forms of technical communication adhering to principles of effective writing and netiquette	P10, P11, P12	C4, C5, A3	Lectures Discussions Exercise	Assignment Final Exam
CO3	Demonstrate enhanced reading skills by employing effective comprehension strategies and analytical practices	P9, P10, P12	C5, A2, A3	Lectures Discussions Exercise	Incourse Final Exam
CO4	Demonstrate improved listening and speaking abilities through interactive	P9, P10, P12	C5, A2, A3	Lectures Discussions Exercise	Incourse Final Exam

	techniques and strategic practice				

14.5.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
						✓					✓	✓	✓				✓	✓	

14.5.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1	Introduction to General English, English as Second Language, English as Foreign Language, English as Lingua Franca, Globalization and English. Extempore Speech.	CO1, CO4
1-2	2-3	Common Mistakes in English: Errors Which Usually Occur in Sentences, Problems with Different Parts of Speech with Special Reference to Verbs, Some Problems in Usage	CO1, CO2
2-3	4-5	English Phonetics: Ways of Correct English Pronunciation, The Speech Sounds of English Language, Differences and Similarities Between the Speech Sound of English and Bengali, The Vowels, Consonants and Diphthongs, Phonetic Transcription of Some Words	CO3, CO4
3	6	Picture Description Review of Right Form of Verbs	CO1, CO4
4	7	Dialogue Writing: What is a Dialogue? Points That We Need to Keep in Mind While Writing Dialogue on a Given Topic Concept of Effective Presentation, Stress, Intonation and Pitch in English	CO2, CO4
	8	Dialogue: Practice in Pair/Group Review of Modal Auxiliary Verbs	CO1, CO3
5	9	Reading Strategies (Annotation, Previewing, Skimming, Scanning, Inferencing etc.), Review of Voice Change, Review of Subject-Verb Agreement	CO1, CO3
	10	Reading Test (In-class Activity), Review of Narration	CO3
6	11	Writing Summary, Writing Precis, Vocabulary Development, Review of Transformation of Sentences	CO1, CO2
	12	General Strategies for the Writing Process: Generating Ideas, Identifying Audiences and Purposes, Planning, Drafting and Finalizing Paragraph Writing: What is a Paragraph?	CO2

		Topic Sentence, Connectives, Order and Unity in a Paragraph	
7	13	Writing Paragraph in Pair/Group Review of Tag Questions	CO1, CO2
	14	Strategies for Oral Presentation Oral Presentation	CO4
8	15-16	Composition: Thesis Sentence, Organization, Linking Expressions, Writing Guided Compositions Following Some Hints, Writing Compositions on Current Affairs	CO2
9	17	Writing Cause & Effect Essay & Feedback, Writing Compare & Contrast Essay & Feedback, Figures of speech in English (Simile, metaphor, irony, hyperbole, allusion etc.)	CO2, CO3
	18	Writing Argumentative Essay & Feedback Review of the Use of Suffixes and Prefixes	CO1, CO2
10	19-20	Discussion on Short Stories: The Happy Prince, Shooting an Elephant, The Verger, The Old Man and The Sea	CO3, CO4
11	21	Discussion on the Idea of a University by Henry Cardinal Newman Strategies for Effective Debate	CO3, CO4
	22	Debate on the Themes of the Short Stories	CO4
12	23	Oral Presentation	CO4
	24	Strategies for Listening Listening Test (IELTS Simulation)	CO2, CO4
13	25	Report/Term Paper: Types & Layout	CO2
	26	Commercial Correspondence: Nature of Communication, Process of Communication, Types Communication Based on Different Parameters (Mode, Medium, Purpose, Number of Interactants), Types of Communication Based on Flow of Information, Influence Gender on Communication, Principles of Effective Communication Writing Complaint Letters	CO2
14	27	Commercial Correspondence: Defining Context, Feedback, Different Parts of a Letter, Sales, Claim and Adjustment Letters	CO2
	28	Business Letter: Job Application Letter (Cover letter, CV, Resume, and Biodata), Quotation Letter, Tender Notice	CO2

14.5.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.5.8 Text Books and Reference Books

1) A Practical English Grammar, A. J. Thomson and A. V. Martinet, Oxford University Press.

2) Effective reading, G. Simon and M. Swan, Cambridge University Press.

3) Most Common mistakes in English Usage, T. J. Berry, McGraw-Hill.

4) Practicing Faster Reading, G. Mosback and V. Mosback, McGraw-Hill.

5) From Paragraph to Essay, M. Imhoof, H. Hudson, Harlow Longman.

6) Commercial Correspondence and Report Writing, R. C. Sharma and Mohan Krishna, Tata-McGraw-Hill.

14.6 Electrical Circuit Analysis Laboratory

14.6.1 Introduction of the Course

Course Code and Title: 0713-EEE-1102 Electrical Circuit Analysis Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course is designed to provide students with hands-on experience in analyzing and designing electrical circuits. It bridges the gap between theoretical concepts and practical applications, enabling students to develop a deeper understanding of circuit behavior and performance. The laboratory experiments reinforce the knowledge gained in lectures and help students to develop essential skills in using electrical measurement instruments and interpreting experimental data.

Prerequisites (if any): No prerequisite.

14.6.2 Course Objectives

The students are expected to

1) Equip themselves with the skills to operate and utilize various laboratory equipment essential for electrical measurements and analysis.

2) Provide hands-on experience in applying and validating fundamental circuit theory laws and theorems.

3) Develop their abilities to analyze experimental data, design electrical circuits, and assess their performance in practical applications.

14.6.3 Course Content

Experiments in relevance with the : Electrical Circuit Analysis course.

Projects related to 0713-EEE-1101: Electrical Circuit Analysis course contents to achieve specific program outcomes.

14.6.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand and use laboratory equipment effectively for electrical measurements and analysis	PO1, PO2	C1, C3, P3, P4	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, Viva, Practical Exams
CO2	Verify and apply fundamental circuit theory laws and theorems in practical scenarios	PO1, PO3	C3, C4, P3, P5	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, In-lab Assessment, Viva
CO3	Analyze and interpret experimental data to design and evaluate electrical circuits for various applications	PO2, PO3, PO4	C4, C5, C6, P6, P7	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, In-lab Assessment, Viva, Quiz

14.6.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		

14.6.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs

1	Experiment 01	Introduction to laboratory equipment (Multimeter, Power Supply, etc.)	CO1
2-3	Experiment 02	Verification of Circuit Theory Laws (KVL, KCL, etc.)	CO2
4-5	Experiment 03	Fundamental Circuit Theory Theorems	CO2
6	Experiment 04	Introduction to Oscilloscope and Signal Generator	CO1
7-8	Experiment 05	Single Time Constants Circuits	CO2
9-11	Experiment 06	Second Order Switched RLC Circuits	CO2, CO3
12-14	Experiment 07	Sinusoidal Steady-State Filters	CO3

14.6.7 Assessment Pattern/ Strategy

Assessment will be based on a variety of methods to evaluate the students' understanding and practical skills, demonstrating their proficiency in both theoretical and practical aspects of electrical circuit analysis and their ability to apply circuit theory laws and theorems.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.6.8 Text Books and Reference Books

1) Fundamentals of Electric Circuits by Charles Alexander, Matthew Sadiku.

2) Electronic Devices and Circuit Theory by Louis Nashelsky and Robert Boylestad.

14.7 Computer Aided Engineering Drawing

14.7.1 Introduction of the Course

Course Code and Title: 0732-CIV-1112: Computer Aided Engineering Drawing.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course introduces engineering graphics and computer-aided design (CAD) using a 3D solid modeling software package and provides students with a comprehensive understanding and practical proficiency in computer-aided engineering drawing using AutoCAD. Topics include fundamental drawing tools, editing techniques, and features like geometric construction, sketching, orthographic projection, isometric, sectional and detailed views, geometric dimensioning and tolerancing, engineering drawings and assemblies. Students will gain the ability to create, edit, and annotate engineering drawings, preparing them for real-world applications and enhancing their proficiency in computer-aided design for various engineering disciplines.

Prerequisites (if any): No prerequisite.

14.7.2 Course Objectives

The students are expected to

1) Develop confidence and proficiency in utilizing the AutoCAD software for engineering design.

2) Demonstrate the ability to create precise engineering drawings using fundamental entities and various editing tools for effective design modification.

3) Acquire hands-on experience in creating complex geometric shapes, applying 2D and 3D modeling concepts.

4) Apply their CAD knowledge practically, designing complex 2D and 3D objects in scenarios reflecting real-world engineering applications.

14.7.3 Course Content

Experiments and projects that involve exploring modern AutoCAD software, mastering tools, and utilizing techniques to create engineering drawings and 2D/3D designs.

14.7.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate proficiency in utilizing AutoCAD software by executing essential commands for engineering drawings	PO1, PO5	C3, P3	Lectures, Books and Handouts	Class Assessment
CO2	Exhibit the ability to create precise engineering drawings by utilizing a variety of editing tools in AutoCAD	PO3, PO5	C3, P3, P5	Lectures, Books and Handouts	Class Assessment Assignment
CO3	Demonstrate proficiency in utilizing modern day CAD tools to	PO3, PO5	C6, P4	Lectures, Books and Handouts	Final Exam Assignment

	construct complex 2D and 3D designs				
CO4	Apply AutoCAD knowledge practically to execute real-world projects, effectively addressing diverse engineering challenges	PO2, PO11	C6, A2, P4	Group discussion, Workshop, Project	Project report Presentation/Assessment

14.7.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
				✓	✓			✓	✓		✓				✓		✓		✓

14.7.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Chapters/Modes	Topics	COs
1	Introduction	Familiarize with AutoCAD user interface, customizing user interface, important AutoCAD commands	CO1
2	Drawing Basics in AutoCAD	Draw lines, rectangles, circles, ellipses, arcs, polygons, and polylines, draw entities using the absolute and relative coordinate points; Use Grid, Snip, Orth Mode and Polar Tracking, Snaps and Object Snap Tracking Create Layers and assign properties to it, Zoom and Pan drawings	CO1
3	Editing Tools in AutoCAD	Move, Copy, Rotate, Scale, Trim, Extend, Fillet, Chamfer, Mirro, Explode, Stretch, Polar Array, Offset, Path Array, Rectangular Array tools	CO1
4	Multi View, Dimensions and Annotations	Orthographic, Auxiliary and Named Views; Creating Dimensions, Dimension Style, Adding Leaders, Editing Dimensions	CO1, CO2
5	Parametric Tools	Apply Geometric and Dimensional Constraints, create equations using parameter manager, create	CO1, CO2
6	Section Views	Create Section Views, Hatching, Island Detection tools	CO2
7	Blocks, Attributes and Xerfs	Create and Insert Blocks, purge blocks, use Divide Tools, Insert multiple blocks	CO2

8	Layouts and Annotative Objects	Create layouts, specify space settings, create viewpoints in paper, use annotative objects in viewports	CO2
9	Templates and Plotting	Configure Plotters, create plot style tables, use plot tyles, create tables	CO1, CO2
10	3D Modeling Basics	Create boxes, cylinder, wedges, cones pyramids, spheres, work with dynamic UCS, change view orientation	CO2, CO3
11	Solid Editing and Generating 2D views	Move objects, create 3D arrays mirror objects, fillet edges, generate 2D views of 3D model, create section and detailed view	CO2, CO3
12	Project distribution	Distribution of projects among different teams; Describe specific requirements to be attained during the project	---
13	Project demonstration	Use multimedia and necessary documentation to clearly communicate the project	CO3, CO4
14	Final Exam	Use CAD tool to design complex 2D and 3D objects from different view perspective	CO3

14.7.7 Assessment Pattern/ Strategy

Assessment will be based on evaluating students' ability to create engineering drawings using AutoCAD software, evaluating their proficiency in utilizing various editing tools and commands, and constructing complex 2D and 3D designs.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.7.8 Text Books and Reference Books

1) AutoCAD 2022: Beginner`s Guide (9^{th} Edition).

2) Technical Drawing by Frederick E. Giesecke, Alva Mitcheel, Henry Cecil Spencer, Ivan Leroy Hill, John Thomas Dygdon.

3) Engineering Drawing by D.N. Ghose.

14.8 Modern Physics

14.8.1 Introduction of the Course

Course Code and Title: 0533-PHY-1201: Modern Physics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a deep understanding of the fundamental principles that govern the behavior of the physical universe at both macroscopic and microscopic scales. The course will explore the dual nature of particles and waves, elucidating the particle-like properties of electromagnetic waves and the wave-like properties of particles, which form the basis of quantum mechanics. It covers the essential concepts of quantum mechanics, highlighting the transition from classical mechanics and introducing key equations and principles that describe particle behavior at the quantum level.

Prerequisites (if any): No prerequisite.

14.8.2 Course Objectives

The students are expected to

1) Grasp the concepts of relativity and analyze problems in special relativity.

2) Comprehend the particle-like properties of electromagnetic waves and the wave-like properties of particles.

3) Understand the foundational principles of quantum mechanics and investigate the matter waves.

4) Understand how classical mechanics approximates quantum mechanics and identify situations where quantum mechanical descriptions are necessary.

14.8.3 Course Content

The Special Theory of Relativity: Galilean and Newtonian Relativity, The Michelson-Morley Experiment, Einstein’s Postulates, Consequences of Einstein’s Postulates, The Lorentz Transformation, Time Dilation, Length Contraction, The Velocity Transformation Law, Relativistic Energy-Momentum Relations, Relativity of Simultaneity and Relativistic Dynamics in Four Vector Notation.

The Particle like Properties Wave: Electromagnetic Waves, Black-body Radiation, Photoelectric Effect, Nature of Light, Photon, X-ray, X-ray Diffraction, Compton Effect, Photon and Gravity.

The Wavelike Properties of Particles: de Broglie’s Hypothesis, Matter Wave, How Matter Wave is Described, The Motion of a Wave Packet, Group and Phase Velocity, Particle Diffraction, Particle in a Box, Uncertainty Relationships for Classical Waves, Heisenberg’s Uncertainty Principles and its Applications.

Atomic Structure: The Nuclear Atom, Electron Orbits, Atomic Spectra, The Bohr Atom, Energy Levels and Spectra, Correspondence Principle, Nuclear Motion and Atomic Spectra.

Quantum Mechanics: Classical Mechanics as an Approximation to Quantum Mechanics, The Wave Equation, Time Dependent Schrodinger Equation, Time Independent Schrodinger Equation, Operator and Expectation Value, Particle in a Box, Particle in a Finite Potential Well and Tunneling Effect.

14.8.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Apply the concepts of the Special Theory of Relativity, including time dilation, length contraction, and relativistic dynamics, to solve problems	PO1, PO2	C3, A3	Lectures Handouts Discussions	Incourse Final Exam
CO2	Investigate the dual nature of light and matter by comprehensively understanding phenomena such as the photoelectric effect and de Broglie's hypothesis, employing research-based knowledge to analyze experimental data	PO2, PO4	C4, A2	Lectures Handouts Discussions	Assignment Final Exam
CO3	Formulate and solve quantum mechanical problems using the Schrödinger equation and other foundational principles, illustrating the transition from classical to quantum mechanics and identifying appropriate contexts for quantum	PO1, PO2, PO4, PO12	C5, P4	Lectures Handouts Discussions	Incourse Presentation Final Exam

	mechanical descriptions				

14.8.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓				✓	✓	✓	✓						✓	✓		

14.9.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Galilean and Newtonian Relativity and their limitations, the Concept of Inertial Frame of References, The Michelson-Morley Experiment: the Inconsistencies of *Aether, Concepts of Space and Time,* the Emergence of Special Theory of Relativity, Einstein's Postulates, Consequences of Einstein's Postulates.	CO1
2	3-4	The Need for Treating Space and Time in Equal Footing, The Lorentz Transformation, The Consequence of Lorentz Transformation: The relativity of Simultaneity, Time Dilation, Length Contraction, Relativistic Velocity Transformation, Ultimate Speed of the Universe.	CO1
3	5	Apparent Paradoxes in Special Theory of Relativity: Twin Paradox, the Muon Paradox and the Pole and Barn Problem, etc., The Concept of Four Vector Notation, Position Four Vector, Velocity Four Vector, Energy-Momentum Four Vector, The Concept of Proper Time	CO1
3	6	Introduction to Electromagnetic Wave (EMW), Maxwell's Theory of EM Radiation, The Experimental Demonstration of Wave Nature: Interference and Diffraction, X-Ray Diffraction.	CO2
4	7-8	The Failure of Classical Physics in Explaining the Black-body Radiation, The Maxwell-Boltzmann Distribution, Quantization of Black-body Radiation: Planck's Formulation.	CO2
5	9-10	Failure of Maxwell's Theory of EM Radiation in Explaining X-Ray Spectra and Photoelectric Effect, The Need for Quantization of EM Wave to Explain X-Ray Spectra and Photoelectric Effect, Light-Matter Interaction: How X-ray Loses Energy through Compton Effect.	CO2
6	11-12	The Wave-Particle Duality, de Broglie's Matter Wave Proposal, The Strangeness of Matter Wave: the Loss of Galilean Invariance, The Concept of Probability Wave, The	CO2

		Motion of Wave Packet: Group and Phase Velocity	
7	13-14	The Physical Interpretation Group and Phase Velocity, The Apparent Conflict of Phase Velocity with Special Theory of Relativity, The Experimental Demonstration of Wave Nature of Particle: Davisson–Germer Particle Diffraction Experiment, How Confinement of Particle in Small Spatial Domain Like a Box Fundamentally Affects its Behavior.	CO2
8	15	The Concept of Canonically Conjugate Variables, The Difficulty of Arbitrary Precision in Measuring Canonically Conjugate Variables, The Heisenberg's Uncertainty: Particle and Wave Aspects, The Physical Implications of Heisenberg's Uncertainty Principle.	CO3
8	16	Thomson Model of Atomic Structure, The Rutherford Gold Foil Experiment: The Nuclear Atom, The Nuclear Dimension Estimation, and The Rutherford Scattering Model.	CO3
9	17-18	The Atomic Orbital Instability of Rutherford Model, The Bohr-Sommerfeld Quantization: The Stable Atomic Orbit, The Bohr Model of Atomic Structure, Estimation of Orbital Radius, Velocity of Electron, Energy of Electron inside Hydrogen Atom	CO3
10	19-20	The Success of Bohr Model in Explaining the Atomic Spectra of Hydrogen Atom, How to Recover Classical Physics from Quantum Physics: The Bohr Correspondence Principle, The Reconciliation of Bohr Model with de Broglie's Matter Wave Proposal: Wave-Particle Duality Survives	CO3
11	21-22	Atomic Structure: The Nuclear Atom, Electron Orbits, Atomic Spectra, The Bohr Atom, Energy Levels and Spectra, Correspondence Principle, Nuclear Motion and Atomic Spectra.	CO3
12	23-24	Classical vs. Quantum Mechanics: Fundamental Leap in Our Understanding about Nature, The Postulatory Formulations of Quantum Mechanics, The Fundamental Postulates of Quantum Mechanics, General Comments of Its Regime of Applications, Introductory Remarks on Different Formulations of Quantum Mechanics.	CO3
13	25-26	The Schrodinger Wave Mechanics Formulation of Quantum Mechanics: Time Dependent and Time Independent Schrodinger Equation , The Concept of Quantum Mechanical Wave function, The Relation Between de Broglie's Matter Wave and Quantum Mechanical Wave function, The Quantum Mechanical Operator, Estimation of Expected Value of Quantum Mechanical Operator	CO3
14	27-28	The Eigen Value Formulation of Schrodinger Equation, The Particle Confinement Problem: Infinitely Hard Wall and Finite Hard Wall, The Concept of Stationary States,	CO3

		Estimation of Stationary States by Solving Time Independent Schrodinger Equation, The Tunneling Effect	

14.8.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.8.8 Text Books and Reference Books

1) Concepts of Modern Physics, 6th Edition, Arthur Beiser, McGraw-Hill.

2) Modern Physics from α to Z, James William Rohlf, John Wiley & Sons.

3) Modern Physics, 3rd Edition, Kenneth S. Krane, John Wiley & Sons, INC.

4) Fundamentals of Physics I and II, R. Shankar, Yale University Press.

14.9 Optics

14.9.1 Introduction of the Course

Course Code and Title: 0533-PHY-1203: Optics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the fundamental principles governing the behavior of light and its applications. Beginning with the exploration of wave motion and its representations, the course progresses to cover the nature and propagation of light, encompassing electromagnetic waves, reflection, refraction, polarization, interference and diffraction. The course concludes with an introduction to optical fibers, covering their structure, types, and relevant parameters. This course aims to equip students with the knowledge and skills essential for understanding and manipulating light in various optical systems.

Prerequisites (if any): No prerequisite.

14.9.2 Course Objectives

The students are expected to

1) Develop a profound understanding of wave motion, including one-dimensional waves, harmonic waves, and the superposition principle.

2) Comprehend the nature and propagation of light, exploring electromagnetic waves, and phenomena such as Rayleigh scattering, reflection, and refraction.

3) Understand polarization phenomena, as well as the practical applications of polarizers and optical modulators.

4) Acquire knowledge of interference and diffraction principles, including interferometry techniques, and single and double-slit diffraction phenomena.

5) Familiarize themselves with the basics of optical fiber technology, covering the structure, types, numerical aperture, and loss mechanisms in optical fibers.

14.9.3 Course Content

Wave Motion: One-Dimensional Waves, Harmonic Waves, Complex Representation of Waves, The Superposition Principle, Phasors and the Addition of Waves, Plane Waves, Spherical Waves and Cylindrical Waves.

The Nature and Propagation of Light: Electromagnetic Waves, Energy and Momentum in EM Wave, Rayleigh Scattering, Reflection, Refraction, Fermat's Principle and Total Internal Reflection.

Geometrical Optics: Lenses, Stops, Mirrors, Prisms, Analytical Ray Tracing, Monochromatic Aberration, Spherical Aberration.

Polarization: The Nature of Polarized Light-Linear, Circular and Elliptical Polarization, Polarizers, Malus's Law, Dichroism and Dichroic Crystal, Polaroid, Birefringence, Polarization by Reflection and Scattering, Circular Polarizers, Optical Activity and Optical Modulators.

Interference: Principle of Superposition, Conditions for Interference, The Wavefront and Amplitude Splitting Interferometry, The Michelson Interferometer, The Mach–Zehnder Interferometer and Newton's Ring Experiment.

Diffraction: The Huygens–Fresnel Principle, The Difference between Fraunhofer and Fresnel Diffraction, Single and Double Slit Fraunhofer Diffraction, How Diffraction Limits Resolution in Imaging System and Diffraction Grating.

Introduction to Optical Fiber: Optical Fiber Structure, Numerical Aperture, Types of Optical Fiber: Step Index and Graded Index Fiber, The Coherent Bundle, Attenuation in Optical Fiber, Pulse Dispersion in Optical Fiber and Loss Mechanisms in Optical Fiber.

14.9.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate proficiency in applying concepts related	PO1	C1, C3	Lectures Discussions Handouts	Incourse Final Exam

	to wave motion in solving practical problems				
CO2	Analyze and comprehend the behavior of light to interpret and explain optical phenomena in various scenarios	PO2	C4	Lectures Discussions	Presentation Final Exam
CO3	Apply knowledge of polarization phenomena and interference principles to design and manipulate optical systems for specific applications	PO3	C3, P5	Lectures Exercise Handouts	Assignment Incourse Final Exam

14.9.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓	✓	✓			✓	✓		✓				✓	✓	✓		

14.9.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Wave Motion: One-Dimensional Waves, Harmonic Waves, Complex Representation of Waves, The Superposition Principle, Phasors and the Addition of Waves, Plane Waves, Spherical Waves and Cylindrical Waves.	CO1
3-4	5-8	The Nature and Propagation of Light: Electromagnetic Waves, Energy and Momentum in EM Wave, Rayleigh Scattering, Reflection, Refraction, Fermat's Principle and Total Internal Reflection.	CO1
5	9-10	Geometrical Optics: Lenses, Stops, Mirrors, Prisms, Analytical Ray Tracing, Monochromatic Aberration, Spherical Aberration.	CO1
6-7	11-14	Polarization: The Nature of Polarized Light - Linear, Circular and Elliptical Polarization, Polarizers, Malus's Law, Dichroism and Dichroic Crystal, Polaroid, Birefringence, Polarization by Reflection and Scattering.	CO2

8	15-16	Circular Polarizers, Optical Activity and Optical Modulators. Interference: Principle of Superposition, Conditions for Interference.	CO2
9-10	17-20	The Wavefront and Amplitude Splitting Interferometry, The Michelson Interferometer, The Mach–Zehnder Interferometer and Newton's Ring Experiment.	CO2
11-12	21-24	Diffraction: The Huygens–Fresnel Principle, The Difference between Fraunhofer and Fresnel Diffraction, Single and Double Slit Fraunhofer Diffraction, How Diffraction Limits Resolution in Imaging System and Diffraction Grating.	CO2 CO3
13-14	25-28	Introduction to Optical Fiber: Optical Fiber Structure, Numerical Aperture, Types of Optical Fiber: Step Index and Graded Index Fiber, The Coherent Bundle, Attenuation in Optical Fiber, Pulse Dispersion in Optical Fiber and Loss Mechanisms in Optical Fiber.	CO3

14.9.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.9.8 Text Books and Reference Books

1) Optics, 5th Edition, Eugene Hecht, Pearson Education Limited.

2) Optics, 1st Edition, Ajoy Ghatak, McGraw-Hill.

3) Fundamentals of Optics, 4th Edition, Francis Arthur Jenkins and Harvey Elliott White.

4) An Introduction to Fiber Optics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press.

14.10 Computer Programming

14.10.1 Introduction of the Course

Course Code and Title: 0613-CSE-1205: Computer Programming.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive foundation in both procedural and object-oriented programming, focusing on C and C++. This course aims to equip students with the essential skills and knowledge required to solve complex computational problems using data structures and algorithms. By understanding the principles of data representation, algorithm performance, and efficient coding practices, students will be prepared to tackle real-world programming challenges. The inclusion of data structures ensures that students develop a robust understanding of the underlying mechanisms that drive software development.

Prerequisites (if any): No prerequisite.

14.10.2 Course Objectives

The students are expected to

1) Develop a strong understanding of basic syntax, control structures, data types, and core programming concepts in both C and C++, enabling them to write and comprehend programs.

2) Acquire practical skills in implementing and manipulating essential data structures, and learn to leverage their efficiencies and applications in problem-solving.

3) Understand and analyze the performance of various algorithms to write efficient and optimized code.

4) Utilize object-oriented programming concepts in C++ to design and implement modular, reusable, and maintainable software solutions.

5) Develop problem-solving skills by applying programming knowledge to real-world scenarios, enabling students to design, implement, and test robust software systems effectively.

14.10.3 Course Content

Data Structure and Algorithm: Data Representations, Data Types and Data Structures, Abstract Data Types, Arrays, Linked-Lists, Stacks, Queues, Priority Queues, Trees, Graphs and their Related Algorithms, Different Types of Search and Sorting Algorithms, Algorithm Performance- Time-Space Complexity.

Programming in C: Overview of C, Constants, Variables and Data Types, Operators and Expressions, Input and Output Functions, Decision Making and Branching Structures- if, else-if, switch, goto, etc., The Loop Control Structures - For-Loop, Do-While Loop and While Loop, User Defined Functions, Recursion and Iterations, Arrays and 2D Array, Structures and Unions, Pointers, Searching, Sorting Techniques, Linked List using C, File Management using C- Creating, Reading Writing and Appending, File Related Different Functions.

Object Oriented Programming (OOP) using C++: Introduction, Importance of OOP, Classes and Objects, Polymorphism, Function and Operator Overloading, Inheritance.

14.10.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Demonstrate proficiency in writing and debugging C and C++ programs that utilize fundamental programming constructs	PO1, PO2	C3, P3	Lectures Discussions	Assignment Presentation
CO2	Implement and manipulate data structures to solve computational problems and understand their practical applications and performance implications	PO2, PO3	C3, C4, P4	Exercise Handouts	Incourse Final Exam
CO3	Evaluate and optimize algorithms for searching, sorting, and other operations, and implement these algorithms in C and C++ to improve program efficiency	PO2, PO3, PO4	C4, C5, P4, P5	Lectures Discussions	Incourse Final Exam
CO4	Design and implement modular, reusable, and maintainable software solutions using object-oriented programming principles in C++ to address real-world problems	PO3, PO5, PO9	C5, C6, A3, A4, P6	Lectures Discussions	MiniProject/ Assignment

14.10.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓			✓				✓		✓		✓	✓				✓		✓

14.10.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Overview of C programming language: Constants, variables, and data types, Operators and expressions, Basic input/output functions	CO1
2	3-4	Decision making and branching structures if, else-if, switch statements Loop control structures (for, while, do-while), Programming exercises	CO1
3	5-6	User-defined functions, Function parameters and return types, Recursion vs iteration, Scope and lifetime of variables	CO1
4	7-8	Arrays and array operations, 2D arrays, Array manipulation algorithms, Practice problems on arrays	CO1 CO2
5	9-10	Introduction to data structures, Abstract Data Types (ADTs), Time and space complexity basics, Algorithm analysis fundamentals	CO2 CO3
6	11-12	Searching algorithms (Linear and Binary Search), Sorting algorithms (Bubble, Selection, Insertion), Implementation in C ,Performance analysis	CO2 CO3
7	13-14	Structures and unions in C, Pointers fundamentals, Dynamic memory allocation, Pointer arithmetic	CO1 CO2
8	15-16	Linked Lists implementation in C, Single and double linked lists, Operations on linked lists, Applications of linked lists	CO1 CO2
9	17-18	Stacks and queues, Priority queues, Implementation using arrays and linked lists, Applications and problem solving	CO2
10	19-20	File management in C, File operations (create, read, write, append), File handling functions, Error handling in file operations	CO1
11	21-22	Introduction to OOP concepts, Classes and objects in C++, Access specifiers, Constructors and destructors	CO1 CO4
12	23-24	Function overloading, Operator overloading, Type conversion, Friend functions	CO4
13	25-26	Inheritance in C++, Types of inheritance, Virtual functions, Abstract classes	CO4

14	27-28	Trees and graphs, Basic tree and graph operations, Implementation in C++, Advanced data structure applications	CO2 CO4

14.10.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Mini project/Presentation: There will be a mini project and presentation associated to this course.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.10.8 Text Books and Reference Books

1) Data Structures with C, Seymour Lipschutz, McGraw-Hill Education.

2) C: The Complete Reference, 4th Edition, Herbert Schildt, McGraw-Hill Education.

3) Teach Yourself C, 3rd Edition, Herbert Schildt, McGraw-Hill.

4) Programming in ANSI C, 7th Edition, E. Balagurusamy, McGraw-Hill.

14.11 Chemistry

14.11.1 Introduction of the Course

Course Code and Title: 0531-CHE-1207: Chemistry.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students in the EEE department a comprehensive introduction to the atomic and molecular structure, chemical bonding, periodic properties of element, reaction kinetics, thermochemistry, Phase transformations and other essential chemical concepts. By grasping these foundational principles, students will be equipped to apply chemical knowledge in various engineering contexts, including materials science, energy production, and environmental sustainability.

Prerequisites (if any): No prerequisite.

14.11.2 Course Objectives

The students are expected to

1) Develop a thorough understanding of the atomic structure, describe the historical development of atomic theory, the periodic table, and the significance of chemical formulas.

2) Investigate Atomic Spectra, derive Schrödinger Equation and the underlying principles of electron orbitals with electron configurations.

3) Explore and differentiate between various types of chemical bonding and the theoretical models that describe molecular shapes.

4) Utilize the principles of reaction kinetics, thermochemistry, and phase transformations to address and solve practical chemical problems in engineering applications.

5) Analyze chemical equilibria, acid-base properties, pH measurements, buffer solutions, titration, and catalysis concepts.

14.11.3 Course Content

Structure of the Atom: Atom, Atomic Masses, Atomic Nucleus, Nuclear Binding Energy, Nuclear Stability, The Periodic Table, Elements and Compounds, Chemical Formulas.

Evolution of Atomic Theory: Thomson and Rutherford Model, Bohr Model of Hydrogen, Bohr-Sommerfeld Model and Multi-electron Atoms, Atomic Spectra, Schrödinger Equation, Electron Orbitals, Aufbau Principle, Pauli Exclusion Principle, and Hund's Rules.

Bonding and Molecules: Primary Bonding: Ionic, Covalent, Metallic. Secondary Bonding: Dipole-dipole, Induced Dipole-Induced Dipole, London Dispersion/van der Waals and Hydrogen Bond.

Shapes of Molecules: Hybridization, LCAO-MO, VSEPR Theory.

Reactions and Kinetics: Reaction Kinetics, Rate Laws, Thermal Activation, and the Arrhenius Equation. Diffusion: Fick's First and Second laws, Homogeneous and Heterogeneous Catalysis.

Phase Transformation and Mixture: Phase Diagram, Thermodynamics of Phase Diagram, Thermodynamics Description of Mixture, Phase Diagram of Binary System.

Redox Reactions: Charge and Electronic Concept, Oxidizing and Reducing Agents, Redox Half Reactions, Rules for Balancing Redox Reactions.

Acids and Bases: Brønsted-Lowry Concept, Lewis Concept, Acid Base Strength, pH, Acid-Base Titration, Indicators, Buffers, Henderson-Hasselbalch Equation, Hard and Soft Acids and Bases.

Thermochemistry: Work, Heat, and Energy, The Internal Energy, Enthalpy, Adiabatic Changes, Exact and Inexact Differentials, Changes in Internal Energy, The Joule–Thomson Effect, Enthalpy, Enthalpies of Formation, Enthalpies of Combustion, Hess's law, Heat Capacity and Specific Heat.

14.11.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Explain structure of the atom, describe the historical development of atomic theory, periodic table, and chemical formulas,	PO1, PO2	C1, P1	Lectures Discussions Handouts Exercise	Incourse Final Exam
CO2	Investigate atomic Spectra, derive Schrödinger Equation and principles governing electron orbitals with electron configurations	PO1, PO3	C1, C2	Lectures Discussions Exercise	Assignment Final Exam
CO3	Analyze different types of chemical bonding and molecular shapes using various theories and principles	PO2, PO3	C4	Lectures Discussions Exercise	Assignment Final Exam
CO4	Apply concepts of reaction kinetics, thermochemistry, phase transformations, and redox reactions to solve practical problems in engineering	PO1, PO2, PO5	C3, A4, P4	Lectures Discussions Exercise	Incourse Final Exam
CO5	Analyze thermochemistry, chemical equilibria, acid-base properties, pH measurements, buffer solutions, titration, and	PO1, PO2, PO3	C3, C4	Lectures Discussions Exercise	Assignment Final Exam

	catalysis concepts.				

14.11.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓					✓		✓					✓		✓		

14.11.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Structure of the Atom: Atom, Atomic Masses, Atomic Nucleus, Nuclear Binding Energy, Nuclear Stability, The Periodic Table, Elements and Compounds, Chemical Formulas.	CO1
2-3	3-6	Evolution of Atomic Theory: Thomson and Rutherford Model, Bohr Model of Hydrogen, Bohr-Sommerfeld Model and Multi-electron Atoms, Atomic Spectra, Schrödinger Equation, Electron Orbitals, Aufbau Principle, Pauli Exclusion Principle, and Hund's Rules	CO2
4-5	7-10	Bonding and Molecules: Primary Bonding: Ionic, Covalent, Metallic. Secondary Bonding: Dipole-dipole, Induced Dipole-Induced Dipole, London Dispersion/van der Waals and Hydrogen Bond.	CO3
6	11-12	Shapes of Molecules: Hybridization, LCAO-MO, VSEPR Theory.	CO3
7-8	13-16	Reactions and Kinetics: Reaction Kinetics, Rate Laws, Thermal Activation, and the Arrhenius Equation. Diffusion: Fick's First and Second laws, Homogeneous and Heterogeneous Catalysis	CO4
9-10	17-20	Phase Transformation and Mixture: Phase Diagram, Thermodynamics of Phase Diagram, Thermodynamics Description of Mixture, Phase Diagram of Binary System.	CO4
11	21-22	Redox Reactions: Charge and Electronic Concept, Oxidizing and Reducing Agents, Redox Half Reactions, Rules for Balancing Redox Reactions	CO4
12	23-24	Acids and Bases: Brønsted-Lowry Concept, Lewis Concept, Acid Base Strength, pH, Acid-Base Titration, Indicators, Buffers, Henderson-Hasselbalch Equation, Hard and Soft Acids and Bases	CO5
13-14	25-28	Thermochemistry: Work, Heat, and Energy, The Internal Energy, Enthalpy, Adiabatic Changes, Exact and Inexact	CO5

		Differentials, Changes in Internal Energy, The Joule–Thomson Effect, Enthalpy, Enthalpies of Formation, Enthalpies of Combustion, Hess's law, Heat Capacity and Specific Heat.	

14.11.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.11.8 Text Books and Reference Books

1) Physical Chemistry, 11th Edition, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press.

2) Chemical Principles: The Quest for Insight, 7th Edition, Peter Atkins, Loretta Jones and Leroy Laverman, W. H. Freeman Publisher.

3) Essential of Physical Chemistry, Arun Bahl, B.S. Bahl, G.D Tuli, Publisher: S. Chand

4) S. Z. Haider- Introduction to Modern Inorganic Chemistry.

5) Modern Inorganic Chemistry by Dr. R. D. Madan.

14.12 Vector Calculus and Complex Analysis

14.12.1 Introduction of the Course

Course Code and Title: 0541-MAT-1209: Vector Calculus and Complex Analysis.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Vector Calculus and Complex Analysis are fundamental tools in electrical and electronic engineering, providing essential mathematical frameworks for understanding and solving complex problems in electromagnetics, signal processing, and control systems. This course aims to equip students with a solid foundation in vector calculus for analyzing vector fields and understanding physical phenomena, as well as complex analysis for solving complex-variable problems that arise in engineering contexts.

Prerequisites (if any): 0541-MAT-1105: Differential and Integral Calculus.

14.12.2 Course Objectives

The students are expected to

1) Develop a strong understanding of vector differential calculus concepts, including inner and cross products, vector and scalar functions, gradients, divergences, and curls.

2) Gain proficiency in applying vector integral calculus, including line, surface, and triple integrals, and understand the applications of Green's, Gauss's, and Stokes's theorems.

3) Explore the geometric representation of complex numbers, understand analytic functions and the Cauchy-Riemann equations, and solve Laplace’s equation and related complex functions.

4) Master the techniques of complex integration, including line integrals in the complex plane, Cauchy's integral theorems, and series expansions, and apply residue integration methods to solve real and complex integrals.

14.12.3 Course Content

Vector Calculus

Vector Differential Calculus: Vectors in 2-Space and 3-Space, Inner Product, Cross Product, Vector and Scalar Functions and their Fields, Derivatives, Curves, Arc Length, Curvature, Gradient of a Scalar Field. Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.

Vector Integral Calculus: Line Integrals, Path Independence of Line Integrals, Green’s Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Gauss Divergence Theorem, Stokes’s Theorem, Applications of Gauss Divergence and Stokes’s Theorem.

Complex Analysis

Complex Numbers, Functions and Differentiation: Complex Numbers and their Geometric Representation, Derivative, Analytic Function Cauchy–Riemann Equations, Laplace’s Equation, Exponential Function, Trigonometric and Hyperbolic Functions, Euler’s Formula, Logarithm, General Power and Principal Value.

Complex Integration: Line Integral in the Complex Plane, Cauchy’s Integral Theorem and Formula, Power Series, Taylor and Maclaurin Series, Laurent Series Pole Singularities and Zeros, Cauchy’s Residue Theorem, Residue Integration Method, Residue Integration of Real Definite Integrals.

14.12.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Analyze and apply vector differential	PO1, PO2, PO4	C3, C4	Lectures Discussions Handouts	Incourse Final Exam

	calculus concepts to solve problems involving vector and scalar fields			Exercise	
CO2	Evaluate and solve vector integral calculus problems using integrals, and apply Green's, Gauss's, and Stokes's theorems in engineering contexts	PO1, PO2, PO4	C5	Lectures Discussions Exercise	Assignment Final Exam
CO3	Demonstrate a comprehensive understanding of complex numbers and functions	PO1, PO2, PO12	C2	Lectures Discussions Exercise	Assignment Final Exam
CO4	Execute complex integration techniques to solve real and complex integrals and apply these methods to practical engineering problems	PO1, PO2, PO4, PO5	C3	Lectures Discussions Exercise	Incourse Final Exam

14.12.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓					✓	✓	✓	✓					✓	✓		✓

14.12.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Vectors in 2-Space and 3-Space, Inner Product, Cross Product, Vector and Scalar Functions and their Fields	CO1
2	3-4	Derivatives, Curves, Arc Length, Curvature, Gradient of a Scalar Field. Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.	CO1

3-4	5-8	Vector Integral Calculus: Line Integrals, Path Independence of Line Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals	CO2
5-6	9-12	Triple Integrals, Gauss Divergence Theorem, Stokes's Theorem, Applications of Gauss Divergence and Stokes's Theorem.	CO2
7	13-14	Complex Numbers, Functions and Differentiation: Complex Numbers and their Geometric Representation, Derivative, Analytic Function Cauchy–Riemann Equations	CO3
8-10	15-20	Laplace's Equation, Exponential Function, Trigonometric and Hyperbolic Functions, Euler's Formula, Logarithm, General Power and Principal Value.	CO3
11	21-22	Complex Integration: Line Integral in the Complex Plane, Cauchy's Integral Theorem and Formula	CO4
12	23-24	Power Series, Taylor and Maclaurin Series, Laurent Series Pole Singularities and Zeros	CO4
13-14	25-28	Cauchy's Residue Theorem, Residue Integration Method, Residue Integration of Real Definite Integrals.	CO4

14.12.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.12.8 Text Books and Reference Books

1) Mathematical Methods for Physics and Engineering, 3rd Edition, K. F. Riley, M. P. Hobson, and S. J. Bence, Cambridge University Press.

2) Advanced Engineering Mathematics, 10th Edition, Erwin Kreyszigm Herbert Kreyszig and Edward J. Norminton, John-Wiley and Sons.

3) Mathematical Method for Physicist, 6th Edition, George B. Arfken and Hans J. Weber,

Elsevier Academic Press.

4) Schaum's Outline of Advanced Mathematics for Engineers and Scientists, 1st Edition, Murray R. Spiegel, McGraw Hill.

14.13 Physics Laboratory

14.13.1 Introduction of the Course

Course Code and Title: 0533-PHY-1204: Physics Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course is designed to provide students with hands-on experience in experimental physics, reinforcing theoretical concepts through practical applications. By conducting experiments related to optics, thermodynamics, and fluid mechanics, students will develop essential skills in measurement techniques, data analysis, and scientific reasoning. This course emphasizes developing a deeper understanding of fundamental physical principles and their real-world applications.

Prerequisites (if any): No prerequisite.

14.13.2 Course Objectives

The students are expected to

1) Conduct experiments to determine optical properties such as the refractive index of a prism, wavelength of spectral lines, and resolving power using diffraction grating.

2) Apply experimental techniques to measure physical constants, including Cauchy's constant, radius of curvature of a lens, and specific heat of liquids.

3) Investigate surface tension and contact angle of mercury using Quincke's method.

4) Develop analytical skills to process experimental data, validate theoretical principles, and improve scientific report writing.

14.13.3 Course Content

Experiments in relevance with the 0533-PHY-1203 Optics course.

Projects related to 0533-PHY-1203 Optics course contents to achieve specific program outcomes.

14.13.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Perform optical experiments to determine the angle of prism, minimum angle of dispersion of a prism, find	PO1, PO5	C3, P3	Lectures, Classwork, Experiment	Assignment, Lab reports, Lab test, Viva, Project

	refractive index , wavelength of spectral lines, and resolving power using a spectrometer and diffraction grating				
CO2	Apply experimental methods to measure physical constants such as Cauchy's constant, the radius of curvature of a lens, and the specific heat of liquids	PO1, PO2, PO5	C3, P4	Lectures, Classwork, Experiment	Lab reports, Hardware demonstrati on
CO3	Investigate surface tension and contact angle of mercury using Quincke's method and interpret the results based on theoretical principles	PO1, PO2, PO4	C4, P5	Lectures, Classwork, Experiment	Lab reports, Viva, Quiz, Hardware demonstrati on
CO4	Analyze experimental data, plot relevant graphs, and communicate findings through structured laboratory reports	PO2, PO10, PO12	C4, C5, A3	---	Lab report, Project report, Presentatio n

14.13.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓						✓							✓				

14.13.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments and projects; Formation of groups/teams for design projects and laboratory works	---
2	Experiment 01	To determine the angle of a prism and the refractive index of the material of a prism.	CO1
3	Experiment 02	To determine the wavelength of various spectral lines by a spectrometer using a plane diffraction grating	CO1
4	Experiment 03	Draw the μ vs $\frac{1}{\lambda^2}$ curve to determine the Cauchy's constant and also determine the resolving power	CO2
5	Experiment 04	To determine the radius of curvature of a lens by Newton's Ring method	CO2
6	Experiment 05	Determination of the specific heat of a liquid by the Newton's cooling law.	CO2
7	Experiment 06	Determination of the surface tension of mercury and angle of contact by Quincke's method	CO3
8-10	Experiments	Review of Experiment 01 to Experiment 06	CO1-CO3
11-14	Evaluation	Viva, Quiz, Hardware demonstration on Experiment 01 to Experiment 06	CO1-CO4

14.13.7 Assessment Pattern/ Strategy

Assessment will be based on the successful execution of optical experiments, accurate measurement and analysis of physical parameters, and the ability to interpret results using theoretical principles. Students will be evaluated on their proficiency in handling laboratory instruments such as spectrometers, diffraction gratings, and optical benches, as well as their ability to collect and analyze experimental data. Emphasis will be placed on scientific report writing, including data presentation, graph plotting, and error analysis.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.13.8 Text Books and Reference Books

1) Advanced Practical Physics for Students: B. L. Worsnop and H. T. Flint.

2) Optics, 5th Edition, Eugene Hecht, Pearson Education Limited.

14.14 Computer Programming Laboratory

14.14.1 Introduction of the Course

Course Code and Title: 0613-CSE-1206: Computer Programming Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: Computer programming, serves as a fundamental cornerstone of modern software development. Understanding core programming concepts and implementing them is essential for developing robust, efficient software solutions. This course provides students with practical knowledge of control structures, data types, and algorithms—skills that are crucial for solving real-world computing problems. Learning C programming builds strong foundations in memory management, data structures, and algorithmic thinking. These skills are transferable to other programming languages and are highly valued in industry. The hands-on approach through practical exercises ensures students can apply theoretical concepts to develop efficient, maintainable code.

Prerequisites (if any): No prerequisite.

14.14.2 Course Objectives

The students are expected to

1) To provide hands-on experience in implementing C programming concepts, control structures, and basic problem-solving techniques using appropriate programming tools.

2) To develop proficiency in designing and implementing various data structures and algorithms with focus on efficiency and optimization.

3) To enable students to create real-world applications using advanced C programming features like pointers, structures, and file handling through practical implementation.

14.14.3 Course Content

Experiments in relevance with the CSE 1201 Computer Programming course.

Projects related to CSE 1201 Computer Programming course contents to achieve specific program outcomes.

14.14.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Apply fundamental C programming concepts to implement and test programs using control	PO1, PO2, PO5, PO9, PO10	C3	Lectures, Coding, Workshop	Assignment/ reports, Lab test, Viva, Project

	structures, functions, and basic input/output operations				
CO2	Implement data structures and algorithms to develop efficient solutions with optimal time-space complexity	PO1, PO2, PO3, PO4, PO5, PO12	C5	Lectures, Simulation, Experiment	Lab reports, assessment during class
CO3	Develop advanced C programs using pointers, structures, arrays, and file handling to solve real-world problems	PO1, PO2, PO3, PO5, PO10, PO11	C6	Group discussion, Project	Project report, Presentation, Viva, Quiz

14.14.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓		✓			✓	✓			✓			✓	✓	✓	✓	✓

14.14.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Examples and problem solving	Fundamentals and Implementation of basic library functions in solving arithmetic formulae	CO1
2	Examples and problem solving	Implementation of If conditions	CO1
3	Examples and problem solving	Implementation of switch cases	CO1
4	Examples and problem solving	Implementation of loops: while,do while, for	CO1
5	Examples and problem solving	Practice on one dimensional arrays	CO2
6	Examples and problem solving	Assessment	CO2

7	Examples and problem solving	Multidimensional Arrays	CO2
8	Examples and problem solving	User defined function and library commands in handling strings	CO2
9	Examples and problem solving	Pointer declaration, array handling with pointers	CO3
10	Examples and problem solving	Recursion	CO2
11	Examples and problem solving	Structures	CO3
12	Examples and problem solving	Basic sorting algorithms	CO2
13	Examples and problem solving	Advanced Concepts and File Operations	CO3
14	Examples and problem solving	LAB final Assessment	CO1-CO3

14.14.7 Assessment Pattern/ Strategy

Assessment will be based on a combination of continuous evaluation and final assessment to ensure students' understanding and practical implementation of C programming concepts. Students will be evaluated on their ability to implement programs accurately and efficiently while adhering to coding standards and proper documentation. Additionally, their participation, problem-solving approach, and debugging skills will be assessed to measure their overall proficiency in applying C programming techniques effectively.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.14.8 Text Books and Reference Books

1) Problem solving and Program Design in C, Authors: Jeri R. Hanly and Elliot B. Koffman.

2) The C Programming Language, Authors: Brian W. Kernighan, Dennis M. Ritchie Publisher: Pearson Edition.

14.15 Chemistry Laboratory

14.15.1 Introduction of the Course

Course Code and Title: 0531-CHE-1208: Chemistry Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course is designed to provide students with hands-on experience in fundamental analytical techniques and methodologies essential for accurate chemical analysis. Through a series of experiments, students will gain practical skills in solution preparation, standardization, and titration methods. This course emphasizes the importance of precision and accuracy in laboratory work, essential for engineering applications, and aims to foster a deeper understanding of chemical principles.

Prerequisites (if any): No prerequisite.

14.15.2 Course Objectives

The students are expected to

1) Gain proficiency in standardizing various chemical solutions, emphasizing the importance of precision and accuracy in laboratory techniques.

2) Develop competence in using titration methods to determine the concentration of different substances, enhancing their analytical skills.

3) Acquire practical skills in handling laboratory equipment and reagents, ensuring safe and efficient experimental procedures.

4) Understand and evaluate the hardness of water and the presence of specific ions in supplied solutions using appropriate indicators and standard solutions.

14.15.3 Course Content

Experiments in relevance with the 0531-CHE-1207: Chemistry course.

14.15.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate the ability to standardize various chemical solutions with precision and accuracy	PO1, PO2	C3, A2, P3	Lectures, Experiment, Group Work	Lab reports, Lab test, Viva
CO2	Apply titration methods to estimate the concentration of substances in different solutions	PO1, PO3	C3, P4	Lectures, Experiment, Group Work	Lab reports, Lab test, Viva

CO3	Develop competency in using laboratory equipment and reagents, ensuring safe and reliable experimental procedures	PO5	C3, A3, P4	Lectures, Experiment, Group Work	Lab reports, Lab test, Viva
CO4	Analyze and evaluate water hardness and the presence of ions using indicators and standard solutions	PO1, PO2, PO4	C4, A4, P5	Lectures, Experiment, Group Work	Lab reports, Lab test, Viva

14.15.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓		✓			✓				✓			✓				

14.15.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments; Formation of groups/teams for laboratory works	---
2	Experiment 01	Standardization of Sodium Hydroxide solution with a standard solution of oxalic acid	CO1, CO3
3	Experiment 02	Standardization of HCl solution with a secondary standard solution of Sodium Hydroxide	CO1, CO3
4	Experiment 03	Standardization of HCl solution with a standard solution of sodium carbonate	CO1, CO3
5	Experiment 04	Standardization of Sodium thiosulphate solution with a standard solution of potassium dichromate	CO1, CO3
6-7	Experiment 05	Estimation of the amount of copper present in the supplied solution by iodometric method	CO2, CO3
8	Experiment 06	Standardization of Potassium Permanganate solution with a standard solution of sodium oxalate	CO1, CO3

9	Experiment 07	Estimation of ferrous ions present in the supplied solution of Ferrous Sulphate by standard Potassium Permanganate solution	CO2, CO3
10-11	Experiment 08	Determination of Total Hardness of Water using Eriochrome Black T as an indicator	CO3, CO4
12-13	Review and Practice	Practice the experiments, Preparation for the final assessment	---
14	Final evaluation	Lab test exam and final viva	---

14.15.7 Assessment Pattern/ Strategy

Students will be assessed based on their successful completion of all experiments and their ability to comprehend the underlying concepts of that particular course. Evaluation will also focus on each individual's proficiency in performing the experiments. Additionally, students will be continuously assessed each week based on their responsiveness to the instructor's questions related to the experiments.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.15.8 Text Books and Reference Books

1) A. I. Vogel - A textbook of quantitative Inorganic analysis.

2) John Wiley and Son's - Vogel's Textbook of Quantitative Chemical Analysis.

3) A. Jabbar Mian and M. Mahbubul Haque - Practical Chemistry.

14.16 Analog Electronics I

14.16.1 Introduction of the Course

Course Code and Title: 0714-EEE-2101: Analog Electronics I.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides a comprehensive understanding of analog electronic components and circuits, emphasizing the theoretical foundations and practical applications of diodes, transistors, and amplifiers. The knowledge gained in this course is essential for students pursuing careers in electronic engineering, as it forms the basis for more advanced studies in analog and digital electronics.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis.

14.16.2 Course Objectives

The students are expected to

1) Understand the construction, operation, and characteristics of semiconductor devices and diode circuits.

2) Develop a thorough understanding of the basic analog circuits including rectifiers, voltage regulators, amplifiers, and switches.

3) Apply knowledge of electronic devices to solve practical problems and implement real-world analog circuit applications.

14.16.3 Course Content

PN Junction Diode and Diode Circuits: Semiconductor Materials, Construction of PN Junction, Formation of Depletion Layer and Barrier Voltage in PN Junction, Current-Voltage Characteristics of a PN Junction Diode, Equivalent Circuit of Diode, Resistance and Capacitance of PN Junction, Diode Circuit and Load Line, Zener Diode Operation and Application, Half -Wave and Full-Wave Rectifier, Voltage Multiplier, Clipper and Clamper.

Bipolar Junction Transistors (BJT): Construction and Operation of BJT, Amplifying Action, Characteristics of BJT in Common Base (CB), Common Emitter (CE) and Common Collector (CC) Configurations, α and β, Q-Point and Load Line, Different Biasing Circuits, Stability Factor, BJT as a Switch, r_e and Hybrid Equivalent Circuit of BJT.

Single Stage BJT Amplifier Circuits: Operation of Single-Stage Amplifier, Voltage and Current Gain, Input and Output Impedance of CB, CE, CC Configurations using h-Parameter, Effect of Unbypassed R_E, R_S.

Field Effect Transistor (FET): JFET Structure, Operation and Characteristics, h-Parameters for JFET, MOSFET Construction, Operation and Characteristics, Biasing Circuits of JFET and MOSFET, Single-stage JFET Amplifier, MOSFET as a Switch, CMOS Inverter.

Multistage and Differential Amplifiers: RC Coupled Two Stage Amplifiers, Direct-coupled Amplifier, Darlington Pair, Multistage Frequency Effects.

Feedback Amplifiers: Principle of Feedback Amplifier, Positive and Negative Feedback, Advantages of Negative Feedback, Gain Stability, Decreased Distortion, Increased Bandwidth, Forms of Negative Feedback, Practical Feedback Circuits.

14.16.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate an understanding of the construction, operation, and characteristics of	PO2	C3	Lectures, Discussions, Handouts	In-Course, Final Exam

	diodes, and explain their applications in rectifiers, voltage regulation, limiting circuits, voltage doublers, and level shifters				
CO2	Describe the principle of operation of BJTs, analyze their characteristics and models, and design and analyze BJT amplifiers and switches	PO2	C3, C4	Lectures, Discussions, Homeworks	Assignment Incourse Final Exam
CO3	Describe the structure and operation of MOSFETs, analyze their I-V characteristics, and design and analyze MOSFET amplifier circuits	PO2	C3, C4	Lectures, Discussions, Handouts	Assignment Incourse Final Exam
CO4	Demonstrate an understanding of the fundamental concepts of frequency response in electronic circuits, analyze high-frequency models of transistors, and evaluate the frequency response of various amplifier stages	PO1	C1, C2, C4	Lectures, Discussions, Handouts	Assignment Incourse Final Exam

14.16.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓				✓	✓	✓									

14.16.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to semiconductor materials, construction of PN junction, formation of depletion layer, and barrier voltage in PN junction	CO1
2	3-4	Current-voltage characteristics of a PN junction diode, equivalent circuit, resistance, and capacitance of PN junction	CO1
3	5-6	Diode circuits and load line analysis, applications of diodes in rectifiers (half-wave and full-wave)	CO1
4	7-8	Voltage regulation using Zener diodes, clippers, and clampers	CO1
5-6	9-12	Construction and operation of BJTs, amplifying action, characteristics of BJT in common base, common emitter, and common collector configurations	CO2
7	13-14	BJT biasing techniques: fixed bias, collector-to-base bias, voltage divider bias, and stability factor	CO2
8	15-16	BJT as a switch, equivalent circuit of BJT, small-signal and large-signal models	CO2
9	17-18	Single-stage BJT amplifier circuits: operation, voltage and current gain, input and output impedance of CB, CE, CC configurations using h-parameters	CO2
10-12	19-24	Structure, operation, and characteristics of JFETs and MOSFETs, biasing circuits, and applications in amplification and switching	CO3
13	25-26	RC coupled, direct-coupled, and Darlington pair amplifiers: analysis and frequency effects	CO3, CO4
14	27-28	Feedback amplifiers: principle, positive and negative feedback, advantages, gain stability, decreased distortion, and increased bandwidt	CO4

14.16.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.16.8 Text Books and Reference Books

1) Electronic Devices and Circuits, 5th Edition, David Bell, Oxford University Press.

2) Electronic Devices and Circuit Theory, Paperback Edition, R. Boylestad and L. Nashelsky, Pearson.

3) Electronic Devices and Circuits, Allen Mottershead, Goodyer Pub. Co.

4) Electronic Principles, Paperback Edition, Albert Malvino and David Bates, McGraw Hill.

5) Electronic Circuits: Discrete and Integrated, Paperback Edition, Donald Schilling, Charles Belove, and Raymond Saccardi, McGraw Hill.

6) Microelectronics, 2nd Edition, Jacob Millman and Arvin Grabel, McGraw Hill.

7) Microelectronic Circuits: Theory and Applications, 7th Edition, Adel S. Sedra, Kenneth C. Smith and Arun N. Chandorkar, Oxford University Press.

14.17 Digital Electronics

14.17.1 Introduction of the Course

Course Code and Title: 0714-EEE-2103: Digital Electronics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of digital systems' fundamental principles and applications, which are the backbone of modern electronic devices and systems. This course equips students with essential knowledge and skills in number systems, logic gates, Boolean algebra, combinational and sequential logic, and interfacing techniques. The integration of programmable logic devices and finite state machines further prepares students for the evolving demands of the electronics industry.

Prerequisites (if any): No prerequisite.

14.17.2 Course Objectives

The students are expected to

1) Understand the distinction between digital and analog quantities, comprehend binary digits, logic levels, digital electronic signals, and gain proficiency in various number systems.

2) Comprehend and apply the operation of fundamental logic gates, programmable and fixed-function logic gates, and Boolean algebra to simplify logical expressions and design combinational logic circuits.

3) Analyze and design arithmetic circuits and implement combinational logic functions for practical applications.

4) Explore sequential logic components, and design various types of shift registers, and synchronous and asynchronous counters.

5) Understand methods of interfacing digital systems with the analog world and compare different integrated-circuit logic families.

14.17.3 Course Content

Introductory Concepts: Digital and Analog Quantities, Binary Digits, Logic Levels, Digital Electronic Signals and Switches, Basic Logic Functions, Combinational and Sequential Logic Functions, Introduction to Programmable Logic and Fixed-Function Logic Devices.

Number Systems, Operations, and Codes: Decimal, Binary, Hexadecimal, Octal and Binary Coded Decimal Number Systems, Binary Arithmetic and Digital Codes.

Logic Gates: Inverter, AND Gate, OR Gate, NAND Gate, NOR Gate, Exclusive-OR and Exclusive-NOR Gate, Universal Gate, Programmable Logic, Fixed- Function Logic Gates.

Boolean Algebra and Logic Simplification: Boolean Operations, Expressions, Laws and Algebra, De Morgan’s Theorems, Boolean Analysis of Logic Circuits, The Karnaugh Map, Don’t Care Conditions, SOP and POS Minimization.

Arithmetic Operations and Circuits: Half and Full Adders, Half and Full Subtractor, 2’s complement, Ripple Carry and Look-Ahead Carry Adders, BCD Adders, Cascading BCD Adders, Multipliers.

Functions of Combinational Logic: Decoders: 1-of-8 decoders, BCD-to-Decimal Decoder/Driver, BCD-to-7-Segment Decoder/Drivers, Decoder IC, Encoders and Applications, Priority Encoders, Code Converters, Magnitude Comparators, Parity Generators/Checkers, Multiplexers: Two, Four, Eight, Sixteen, Quad Two-Input MUX, Multiplexer Applications: Data Routing, Parallel-to-Serial Conversion, Logic Functions Generation, Demultiplexers and its Applications, 1-Line-to-8-Line Demultiplexer, Synchronous Data Transmission.

Sequential Logic: NAND/NOR Gate Latch, Edge-Detector Circuit, Flip-Flops: Clocked S-C Flip-Flop, Clocked J-K Flip-Flop, Clocked D Flip-Flop, T Flip-Flop, Master/Slave Flip-Flop, Clocked J-K Flip-Flop with Asynchronous Inputs, Flip- Flop Applications: Edge Detection, Switch Bouncing Reduction, Parallel Data Transfer, Serial Data Transfer.

Shift Registers and Counters: Shift Register Operations, Types of Shift Register, Shift Register Counters: Ring Counter and Johnson Counter, Asynchronous Counters, IC Asynchronous Counters, Asynchronous Down Counters, Synchronous Up/Down Counters, Pre-settable Counters, Counter with Arbitrary Sequences, Design of Synchronous Counters and Cascaded Counters.

Interfacing with the Analog World: Methods of Digital-to-Analog Conversion: Weighted Resistors Converter, R-2R Ladder Converter, Methods of Analog-to- Digital Conversion: Flash, Digital Ramp, Successive Approximation Converter, ADC and DAC Applications.

Integrated-Circuit Logic Families: Characteristic Parameters, The TTL Logic Family, TTL Series Characteristics, TTL Circuit Operation, Current-Sinking and Sourcing Action, Totem-Pole Output Circuit, TTL Series Characteristics, TTL Loading, Fan-In and Fan-Out, TTL NOR Gate, TTL NAND Gate, Digital MOSFET Circuits: CMOS, NMOS and PMOS Gates, Emitter-Coupled Logic, Direct Coupled Transistor Logic, Resistor Transistor Logic.

Finite State Machines: State Diagram, Moore-type and Melay-type Machines, State Machines Synthesis, State Machines in Verilog, State Encoding.

Introduction to Programmable Logic Device: Programmable Logic Device (PLD), Programmable Logic Array (PLA), Field-Programmable Gate Array (FPGA).

14.17.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a thorough understanding of the distinction between digital and analog quantities, and the various number systems essential for digital electronics	PO1, PO2	C1, C2	Lectures Discussions	Incourse Final Exam
CO2	Apply the principles of fundamental logic gates, Boolean algebra, and programmable logic to design and simplify combinational logic circuits	PO3, PO5	C3, C5	Lectures Discussions Exercise Handouts	Incourse Final Exam
CO3	Analyze and construct arithmetic circuits, and implement combinational logic functions for	PO1, PO3	C3, C4	Lectures Discussions Exercise Handouts	Incourse Final Exam

	diverse practical applications				
CO4	Develop and implement sequential logic circuits, and understand methods for interfacing digital systems with analog environments	PO1, PO3, PO5	C3, C5, C6	Lectures Discussions Exercise Handouts	Assignment Presentation Incourse Final Exam

14.17.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓			✓	✓	✓				✓		✓	✓		✓

14.17.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introductory Concepts: Digital and Analog Quantities, Binary Digits, Logic Levels, Digital Electronic Signals and Switches, Basic Logic Functions, Combinational and Sequential Logic Functions, Introduction to Programmable Logic and Fixed-Function Logic Devices.	CO1
2	3-4	Number Systems, Operations, and Codes: Decimal, Binary, Hexadecimal, Octal, and Binary Coded Decimal Number Systems, Binary Arithmetic and Digital Codes.	CO1
3	5-6	Logic Gates: Inverter, AND Gate, OR Gate, NAND Gate, NOR Gate, Exclusive-OR and Exclusive-NOR Gate, Universal Gate, Programmable Logic, Fixed-Function Logic Gates.	CO2
4	7-8	Boolean Algebra and Logic Simplification: Boolean Operations, Expressions, Laws and Algebra, De Morgan's Theorems, Boolean Analysis of Logic Circuits, The Karnaugh Map, Don't Care Conditions, SOP and POS Minimization.	CO2
5	9-10	Arithmetic Operations and Circuits: Half and Full Adders, Half and Full Subtractor, 2's complement, Ripple Carry and Look-Ahead Carry Adders, BCD Adders, Cascading BCD Adders, Multipliers.	CO3
6-7	11-13	Functions of Combinational Logic: Decoders: 1-of-8 decoders, BCD-to-Decimal Decoder/Driver, BCD-to-7-	CO3

		Segment Decoder/Drivers, Decoder IC, Encoders and Applications, Priority Encoders, Code Converters, Magnitude Comparators, Parity Generators/Checkers, Multiplexers: Two, Four, Eight, Sixteen, Quad Two-Input MUX, Multiplexer Applications: Data Routing, Parallel-to-Serial Conversion, Logic Functions Generation, Demultiplexers and its Applications, 1-Line-to-8-Line Demultiplexer, Synchronous Data Transmission.	
7-8	14-16	Sequential Logic: NAND/NOR Gate Latch, Edge-Detector Circuit, Flip-Flops: Clocked S-C Flip-Flop, Clocked J-K Flip-Flop, Clocked D Flip-Flop, T Flip-Flop, Master/Slave Flip-Flop, Clocked J-K Flip-Flop with Asynchronous Inputs, Flip- Flop Applications: Edge Detection, Switch Bouncing Reduction, Parallel Data Transfer, Serial Data Transfer.	CO4
9-10	17-19	Shift Registers and Counters: Shift Register Operations, Types of Shift Register, Shift Register Counters: Ring Counter and Johnson Counter, Asynchronous Counters, IC Asynchronous Counters, Asynchronous Down Counters, Synchronous Up/Down Counters, Pre-settable Counters, Counter with Arbitrary Sequences, Design of Synchronous Counters and Cascaded Counters.	CO4
10-11	20-22	Interfacing with the Analog World: Methods of Digital-to-Analog Conversion: Weighted Resistors Converter, R-2R Ladder Converter, Methods of Analog-to-Digital Conversion: Flash, Digital Ramp, Successive Approximation Converter, ADC and DAC Applications.	CO4
12-13	23-26	Integrated-Circuit Logic Families: Characteristic Parameters, The TTL Logic Family, TTL Series Characteristics, TTL Circuit Operation, Current-Sinking and Sourcing Action, Totem-Pole Output Circuit, TTL Series Characteristics, TTL Loading, Fan-In and Fan-Out, TTL NOR Gate, TTL NAND Gate, Digital MOSFET Circuits: CMOS, NMOS and PMOS Gates, Emitter-Coupled Logic, Direct Coupled Transistor Logic, Resistor Transistor Logic.	CO4
14	27	Finite State Machines: State Diagram, Moore-type and Melay-type Machines, State Machines Synthesis, State Machines in Verilog, State Encoding.	CO4
14	28	Introduction to Programmable Logic Device: Programmable Logic Device (PLD), Programmable Logic Array (PLA), Field-Programmable Gate Array (FPGA).	CO4

14.17.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum of 1 Assignment or presentation; if 2 or more assignments or presentations are taken then their average will be considered in the final evaluation.

3) Incourse: There will be a minimum of 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in the final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.17.8 Text Books and Reference Books

1) Digital Systems, 12th Edition, Ronald Tocci, Neal Widmer and Greg Moss, Pearson.

2) Digital Fundamentals, 11th Edition, Thomas L. Floyd, Pearson.

3) Digital Electronics: A Practical Approach, 8th Edition, William Kleitz, Prentice Hall.

4) Digital Electronics: Principles, Devices and Applications, Anil K. Maini, John Wiley and Sons Pub. Ltd.

14.18 Solid State Physics

14.18.1 Introduction of the Course

Course Code and Title: 0714-EEE-2105: Solid State Physics

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week

Rationale of the Course: This course is designed to provide a comprehensive understanding of the fundamental principles governing the behavior of solids. It bridges the gap between quantum mechanics and material science, offering essential insights into the properties and behaviors of materials at the atomic level. This knowledge is crucial for advancing various fields such as semiconductor technology, nanotechnology, and materials engineering.

Prerequisites (if any): 0533-PHY-1201: Modern Physics

14.18.2 Course Objectives

The students are expected to

1) Understand the fundamental principles and interactions that determine the structure and properties of solids.

2) Analyze the behavior of electrons and phonons in solids and their contribution to material properties.

3) Explore lattice structures and their role in determining material characteristics.

4) Apply the principles of solid-state physics to explain electron emission and thermoelectric effects in materials.

14.18.3 Course Content

What Holds Solids Together: Ionic Bonds, Covalent Bond, Molecular Orbital, van der Waals bonding, Fluctuating Dipole Forces, Metallic Bonding, Hydrogen Bonds, Covalent, Ionic and Molecular Crystals.

Geometry of Solids: Lattices and Unit Cells, Lattices in Three Dimensions, Bravais Lattice, Primitive Unit Cell, Wigner-Seitz Cell, The Body-Centered Cubic (BCC) Lattice, The Face-Centered Cubic (FCC) Lattice, Reciprocal Lattice, Lattice Planes, Miller Indices, Brillouin Zones, The Laue and Bragg Conditions for X-ray Diffraction, The Structure Factor.

Electrons in Solid: Electrons in a Periodic Potential, Kronig-Penney Model, Bloch's Theorem, Energy Bands in Solids, Reduced and Extended Brillouin Zone, Bandgap, Metal, Insulator and Semiconductor, Direct and Indirect Bandgap Material, The Concept of Hole, Effective Mass of Electron, Group Velocity of Electron.

Phonons in Solid: Crystal Vibrations, Mono and Diatomic Crystal Chain, Atomic Potential, Dispersion and Normal Modes, Quantization of Elastic Waves, Quantum Modes: Phonons and its Spectrum, Long Wavelength Limit, Goldstone Modes, Crystal Momentum.

Free Electron Theory of Metal: The Free Electron Gas, Free Fermi Gas at Absolute Zero Temperature, Fermi-Dirac Distribution, Fermi Surface and Sphere in Metal, The Specific Heat Capacity of Electrons in Metal.

Electron Emission: Work Function, Surface Potential Barrier, Contact Potential, Ohmic and Rectifying Contacts, Thermionic Emission: Richardson-Dushman Equation, Schottky Effect, Field Emission: Fowler-Nordheim Equation, Secondary Emission, Secondary Multipliers, Photoelectric Effect and Emission, Thermo-electricity for Metal and Semiconductors, Electron Ballistics, Lorentz Equation and its Application, Child-Langmuir Three Halves Power Law.

14.18.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate an understanding of bonding mechanisms and lattice structures in solids.	PO1, PO2	C1, C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Analyze the electronic and phononic behavior in solids using Bloch's theorem and the Kronig-Penney model.	PO1, PO2	C4	Lectures Discussions Exercise	Incourse Final Exam

CO3	Evaluate the implications of free electron theory and Fermi surfaces on the thermal and electrical properties of metals.	PO2, PO4	C5	Lectures Discussions Handouts	Final Exam
CO4	Apply the concepts of electron emission and metal semiconductor contact behavior to real-world materials and devices.	PO3, PO5, PO7	C5, A4	Lectures Discussions Handouts	Assignment Final Exam

14.18.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓						✓			✓								

14.18.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Solid State Physics: Overview, importance, and applications of solid-state physics.	---
2	3-4	What Holds Solids Together: Ionic, covalent, metallic, van der Waals bonding, hydrogen bonds.	CO1
3-4	5-8	Geometry of Solids: Lattices and unit cells, Bravais lattices, primitive and Wigner-Seitz cells, Reciprocal lattices, Miller indices, Laue and Bragg conditions, X-ray diffraction.	CO1
5-6	9-12	Electrons in Solids: Electrons in a periodic potential, Bloch's theorem, energy bands in solids, Reduced and extended Brillouin zones, bandgap types, effective mass of electrons.	CO2
7-8	13-16	Phonons in Solids: Crystal vibrations, mono and diatomic crystal chains, atomic potential, Dispersion relations, phonon spectrum, quantization, Goldstone modes.	CO2
9-10	17-20	Free Electron Theory of Metals: Free electron gas model, Fermi-Dirac distribution, Fermi surfaces, Specific heat of electrons, electrical and thermal properties.	CO3

11-12	21-24	Electron Emission: Work function, surface potential barrier, thermionic emission, Schottky effect, Field emission, photoelectric effect, electron ballistics, Lorentz equation.	CO4
13-14	25-28	Metal-Semiconductor contact: Ohmic and rectifying contacts	CO4

14.18.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.18.8 Text Books and Reference Books

1) Solid State Physics, 1st Edition, Neil W. Ashcroft and N. David Mermin, Cengage Learning.

2) The Oxford Solid State Basics, 1st Edition, Steven H. Simon, Oxford University Press.

3) Introduction to Solid State Physics, 8th Edition, Charles Kittel, Wiley.

4) Solid-State Physics: An Introduction to Principles of Materials Science, Harald Ibach and Hans Lüth, Springer.

5) Electronic Properties of Materials, 4th Edition, Rolf E. Hummel, Springer.

6) Band Theory and Electronic Properties of Solids, 1st Edition, John Singleton, Oxford University Press.

7) Electronic Processes in Materials, Leonid V. Azaroff and James J. Brophy, McGraw-Hill.

14.19 Electromechanical Energy Conversion I

14.19.1 Introduction of the Course

Course Code and Title: 0713-EEE-2107: Electromechanical Energy Conversion I.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The course is designed to give a complete concept about electrical energy conversion devices (electrical machines) to the students. In this course, mostly using electrical machines like motor and generator are comprehensively discussed and studied. Further, the fundamental element of power system called transformer is also analyzed with a realistic point of view.

Prerequisites (if any): 0533-PHY-1103: Electricity and Magnetism.

14.19.2 Course Objectives

The students are expected to

1) Understand the fundamental concepts of electromagnetic circuits including magnetic hysteresis, hysteresis loss, leakage flux and distinguish between electrical energy and magnetic energy.

2) Understand the principles of DC motor and DC generator. Identify their varieties and get a clear concept about their construction. Differentiate between DC motor and DC generator. Explain their different characteristics and deduce their governing equations.

3) Calculate the operational losses of DC motor and DC generator and find the efficiencies. Clearly understand speed control mechanism of DC motor.

4) Understand the working principle of transformer. Investigate the construction of Transformer. Calculate different operational loss of transformer. Learn about transformer tests. Get an overview about auto transformer.

5) Learn the construction of three phase transformer. Relate the knowledge of single phase transformer with three phase. Understand different connection scheme of three phase transformers.

14.19.3 Course Content

Electromagnetic Circuits: Magnetic Field, Magnetic Circuit, Comparison between Magnetic and Electric Circuits, Magnetization, Magnetic Hysteresis, Hysteresis Loss, Leakage Flux, Faraday's Laws of Electromagnetic Induction, Induced EMF, Self and Mutual Inductance, AC Excitation in Magnetic Circuit, Eddy Current Loss.

DC Generator: Main Constructional Features, Simple Loop Generator, Commutator, Armature Coils, Brushes, Armature Winding, Characteristics of Lap and Wave Winding, EMF and Torque Equation, Armature Reaction, Methods of Commutation, Types of DC Generators, No-load and Load Characteristics of Shunt, Series and Compound Generators, Losses and Efficiency of DC Generators.

DC Motors: Working Principle of DC Motors, Back EMF and EM Torque, Series and Shunt DC Motors, Starting of Shunt and Compound Wound DC Motors, Speed Control of DC Motors, Electrical Braking of DC Motor, Losses in DC Motor, Efficiency of DC Motor.

Single-Phase Transformers: Working Principle of a Transformer, Core Material and Construction, Transformer Winding, EMF Equation, An Ideal Transformer, Transformer on No-load and Load, Transformer Winding Resistance, Mutual and Leakage Fluxes, Equivalent Reactance, Equivalent Circuit for an Actual Transformer, Voltage Regulation, Losses in a Transformer, Efficiency of a Transformer, Transformer Tests: Voltage Ratio, Open-circuit or No-load Test, Short Circuit Test, Back-to-Back Test, Parallel Operation and Load Sharing of Transformers, Auto-transformer.

Three-Phase Transformers: Merits and Construction of Three Phase Transformer, Relative Primary and Secondary Windings, Polarity of Transformer Windings, Phasor Representation, Three-Phase Transformer Connections, Selection of Transformer Connections: Star-Star, Delta-Delta, Star-Delta Connections, Delta-Star and Delta-Zigzag, Parallel Operation of Three-Phase Transformers, Load Sharing between Three-Phase Transformers, No-load and Load Tap-Changers on Transformers, Transformation of Three-Phase Power with Two Single-Phase Transformers, Open-Delta or V-V and T-T Connections, Conversion of Three-Phase to Two-Phase and Vice-Versa, Difference between Power and Distribution Transformers, Power Transformer.

14.19.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the constructions, working principles and basic features of key electric machines, including DC motor, DC generator, transformer	PO1	C2	Lectures, Interactive discussions, Video tutorials	Incourse exam, Final exam
CO2	Develop and utilize the electrical equivalent circuits for DC motors, DC generators, and transformers and solving mathematical problems	PO2	C3, C4	Lectures, Interactive discussions, Problem solving	Assignment, Incourse exam, Final exam
CO3	Design and analyze the connection diagram of electrical transformer for a particular network	PO3	C3, C6	Lectures, Interactive discussions, Video tutorials,	Assignment, Incourse exam, Final exam
CO4	Study the characteristics of DC motor and DC	PO4	C4	Interactive Discussions,	Incourse exam, Final exam

	generator and figure out its best operational state			Problem solving	

14.19.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓		✓	✓			✓	✓						✓	✓			

14.19.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Magnetic field, magnetic circuit, magnetization, magnetic hysteresis, hysteresis Loss, leakage flux, faraday's laws of electromagnetic induction, self and mutual inductance, AC excitation in magnetic circuit, eddy current loss.	C01
2-3	3-6	Working principle and construction of a transformer, transformer winding, EMF equation, ideal transformer, transformer on no-load and load, transformer winding resistance, mutual and leakage fluxes, equivalent circuit for an actual transformer, voltage regulation.	C01, CO2
4-5	7-10	Losses and efficiency of a transformer, transformer tests: voltage ratio, open-circuit or no-load test, short circuit test, back-to-back test, parallel operation and load sharing of transformers, auto-transformer.	CO2
6	11	Merits and construction of three phase transformer.	C01
6-7	12-13	Polarity of transformer windings, phasor representation, three-phase transformer connections, selection of transformer connections: star-star, delta-delta, star-delta connections, delta-star and delta-zigzag, parallel operation of three-phase transformers.	CO3
7-8	14-16	Load sharing between three-phase transformers, no-load and load tap-changers on transformers, transformation of three-phase power with two single-phase transformers, open-delta or v-v and t-t connections, conversion of three-phase to two-phase and vice-versa, difference between power and distribution transformers, power transformer.	CO2, CO3
9-10	17-20	Main constructional features of DC generator, simple loop generator, commutator, armature coils, brushes, armature winding, characteristics of lap and wave winding, emf and torque equation, armature reaction, methods of commutation, types of dc generators,	C01, CO2
11	21-22	No-load and load characteristics of shunt, series and	CO4

		compound generators, losses and efficiency of dc generators.	
12-13	23-25	Working principle of dc motors, back emf and torque, series and shunt dc motors, starting of shunt and compound wound dc motors.	C01, CO2
13-14	26-28	Speed control of dc motors, electrical braking of dc motor, losses in dc motor, efficiency of dc motor.	CO2, CO4

14.19.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 assignment; if 2 or more assignments are taken then their average will be considered in final evaluation.

3) Incourse Exam: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.19.8 Text Books and Reference Books

1) Electrical Machines, 1st Edition, S. K. Sahdev, Cambridge University Press.

2) Electric Machinery Fundamentals, 5th Edition, Stephen J. Chapman, McGraw-Hill Education.

3) Electric Machinery, 6th Edition, A.E. Fitzgerald, Charles Kingsley JR and Stephen D. Uman, McGraw-Hills.

4) Electric Machines: Theory, Operating Applications, and Controls, 2nd Edition, Charles I. Hubert, Pearson.

5) A Text Book of Electrical Technology, Volume II, AC & DC Machines, B.L. Thereja, A.K. Thereja, 23rd Edition.

14.20 Signals and Systems

14.20.1 Introduction of the Course

Course Code and Title: 0714-EEE-2109: Signals and Systems.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Signals and Systems course is designed to provide a fundamental concept to students that can be used in wide range of applications. Such as communications, control engineering, aeronautics, astronautics, robotics, circuit design, acoustics, seismology, biomedical engineering, energy generation and distribution systems, chemical process control, speech processing, image processing and so on. The physical phenomenon/process in real world that we observed around us can be mathematically described by signals and systems. The knowledge shows us how to design and fabricate entirely new devices/systems. Main purpose of this course is to develop these two concepts and their interaction in sufficient depth that can be applied to the analysis of advanced problems in engineering.

Prerequisites (if any): 0541-MAT-2111: Ordinary and Partial Differential Equations.

14.20.2 Course Objectives

The students are expected to

1) To develop a solid foundation on the signal and systems, and the essential techniques required for their analysis and synthesis for pursuing further studies in the field of telecommunication and signal processing.

2) To study the most widely used techniques for transforming and analyzing signals and systems, both in time domain and frequency domain.

3) To investigate the behavior of linear time invariant (LTI) systems with continuous and discrete time signals as input using various techniques, such as convolution, differential equations and state equations.

4) To explore the analogy between the electrical systems and electromechanical systems, and apply this analogy for problem solving.

14.20.3 Course Content

Signals: Classification of Signals, Basic Operations on Signals, Elementary Signals, The Concept of Frequency in Continuous-Time and Discrete-Time Signals, Analog-to-Digital and Digital-to-Analog Conversion.

Systems: Input-Output Description of Systems, Classification of Systems, Properties of Systems, Interconnection of Systems.

Linear Time-Invariant (LTI) Systems: Response of Continuous-Time LTI System and Convolution Integral, Response of a Discrete-Time LTI System and Convolution Sum, Recursive and Non-Recursive Systems, Differential and Difference Equation Representations of LTI Systems, Solution of Differential and Difference Equations, State Variable Descriptions of LTI Systems, Structures for the Realization of LTI Systems.

Fourier Analysis of Signals and Systems: Fourier Representations of Signals, The Fourier series, The Discrete-Time Fourier Series, The Fourier Transform, The Discrete-Time Fourier Transform, Properties of Fourier Representations, Parseval's Theorem, Power Density Spectrum and Energy Density Spectrum.

Applications of Fourier Analysis: Frequency Response of LTI Systems to Complex Exponential Signals, Filtering and Bandwidth, Frequency Analysis- Analog Electrical Systems, Sampling and Reconstruction of Signal, Convolution and Multiplication with Mixtures of Periodic and Non-periodic Signals, Modulation and Demodulation, Time-Division and Frequency-Division Multiplexing.

The Laplace Transform: Definition, Properties, Convergence of Laplace Transform, Initial-value and Final-Value Theorem, Inverse Laplace Transform, Partial-fraction Expansions, Heaviside Expansion Formula, Solution of Differential Equation, System Transfer Function, System Stability, Electrical Network Analysis.

14.20.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the properties of different continuous and discrete time signals and basic operation on them	PO1	C1, C2, A1	Lectures Handouts Discussions	Incourse Final Exam
CO2	Apply the fundamental concepts of continuous and discrete time signals and basic operation on them to analyze input/output behavior of LTI system in time domain	PO1, PO2	C3, C4	Lectures Handouts Problem solving Discussions	Incourse Final Exam
CO3	Apply the concept of frequency domain transformation (Fourier series and Fourier Transform) of continuous and discrete time signals to analyze LTI system behavior	PO2, PO3	C4, C5	Lectures Handouts Problem solving Discussions	Assignment Final Exam
CO4	Analyze input/output behavior of LTI system using	PO3, PO4	C4, C5, C6	Lectures Handouts Exercise Discussions	Assignment Final Exam

	Laplace transform				

14.20.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓				✓	✓		✓				✓			✓	

14.20.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-3	Signals: classification of signals, Basic operation on Signals, Elementary Signals, The concept of frequency in Continuous time and Discrete-Time signals, Analog-to-digital and digital-to-analog Conversion	CO1
2-3	4-6	Systems: Input-Output Description of Systems, Classification of Systems, Properties of Systems, Interconnection of Systems.	CO1
4-6	7-11	Linear Time-Invariant (LTI) Systems: Response of Continuous-Time LTI System and Convolution Integral, Response of a Discrete-Time LTI System and Convolution Sum, Recursive and Non-Recursive Systems, Differential and Difference Equation Representations of LTI Systems, Solution of Differential and Difference Equations, State Variable Descriptions of LTI Systems, Structures for the Realization of LTI Systems.	CO2, CO3
6-8	12-15	Time domain analysis of LTI Systems: Differential equations-system representation, order of the system, solution techniques, zero state and zero input response, system properties, impulse response, convolution integral, determination system properties, state variable, state equation and time domain solution	CO2, CO3
8-10	16-20	Fourier Analysis of Signals and Systems: Fourier Representations of Signals, The Fourier series, The Discrete-Time Fourier Series, The Fourier Transform, The Discrete-Time Fourier Transform, Properties of Fourier Representations, Parseval's Theorem, Power Density Spectrum and Energy Density Spectrum.	CO3, CO4
11-12	21-24	Applications of Fourier Analysis: Frequency Response of LTI Systems to Complex Exponential Signals, Filtering and Bandwidth, Frequency Analysis- Analog Electrical Systems, Sampling and Reconstruction of Signal, Convolution and Multiplication with Mixtures of Periodic and Non-periodic Signals, Modulation and	CO2, CO4

		Demodulation, Time-Division and Frequency-Division Multiplexing.	
12-14	25-28	The Laplace Transform: Definition, Properties, Convergence of Laplace Transform, Initial-value and Final-Value Theorem, Inverse Laplace Transform, Partial-fraction Expansions, Heaviside Expansion Formula, Solution of Differential Equation, System Transfer Function, System Stability, Electrical Network Analysis.	CO1, CO3, CO4

14.20.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 in-course exam; if 2 or more in-course exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.20.8 Text Books and Reference Books

1) Signals and Systems, 2nd Edition, Alan V. Oppenheim, Alan S. Willsky and S. Hamid, Pearson Education.

2) Signals and Systems, 2nd Edition, Simon Haykin and Barry Van Veen, Wiley Inc.

3) Signals and Systems A Matlab Integrated Approach, by Oktay Alkin, CRC Press, Taylor and Francis Group.

4) Signals and Systems: Theory and Applications by Fawwaz T. Ulaby and Andrew E. Yagle.

5) Linear Systems and Signals, 3rd Edition, B.P. Lathi and Roger Green, Oxford University Press.

6) Signals and Systems, 1st Edition, Sanjit K. Mitra, Oxford University Press

7) Continuous and Discrete-Time Signals and Systems, 2nd Edition, Samir S. Soliman and Mandyam D. Srinath, Prentice-Hall of India.

14.21 Ordinary and Partial Differential Equations

14.21.1 Introduction of the Course

Course Code and Title: 0541-MAT-2111: Ordinary and Partial Differential Equations.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is crucial for EEE students, equipping them with the necessary mathematical tools to model, analyze, and solve complex systems encountered in their field. Differential equations are foundational in understanding the behavior of circuits, control systems, electromagnetic fields, and other dynamic processes. This course not only enhances analytical skills but also prepares students to apply these mathematical concepts in different practical and theoretical engineering problems.

Prerequisites (if any): 0541-MAT-1105: Differential and Integral Calculus.

14.21.2 Course Objectives

The students are expected to

1) Develop a thorough understanding of first-order and higher-order ordinary differential equations (ODEs) and their solutions using various analytical methods.

2) Explore the theory and applications of second-order ODEs, and the use of series solutions.

3) Comprehend and apply fundamental concepts of important partial differential equations (PDEs) such as the wave, diffusion, and Laplace equations in engineering contexts.

4) Utilize advanced techniques to solve PDEs, including separation of variables, integral transforms, and Green's functions, and apply these methods to real-world engineering problems.

14.21.3 Course Content

Ordinary Differential Equations (ODEs)

First-order ODE: General Form of Solution, First-degree First-order Equations, Separable-variable Equations, Exact Equations, Inexact Equations, Integrating Factors, Linear Equations, Homogeneous Equations, Isobaric Equations, Bernoulli’s Equation, Existence and Uniqueness of Solutions for Initial Value Problems, Higher-Degree First-Order Equations, Clairaut’s Equation.

Second-Order ODEs: Homogeneous Linear ODEs of Second Order, Homogeneous Linear ODEs with Constant Coefficient, Euler–Cauchy Equations, Existence and Uniqueness of Solutions, Wronskian, Nonhomogeneous ODEs, Method of Undetermined Coefficients, Solution by Variation of Parameters.

Series Solutions of ODEs: Power Series Method, Legendre’s Equation and Legendre Polynomials, Bessel’s Equation and Bessel Functions, Laguerre Differential Equation and Laguerre Polynomials, Airy Differential Equation, Hermite Differential Equation and Hermite Differential Polynomials.

Partial Differential Equations (PDEs)

Important Partial Differential Equations: The Wave Equation, The Diffusion Equation, Laplace Equation, Poisson’s Equations, Schrodinger’s Equation.

Solving PDEs: General and Particular Solutions, Separation of Variables, Superposition of Separated Solutions, Separation of Variables in Polar Coordinates, Laplace Equation in Polar Coordinates, Spherical Harmonics, Helmholtz's Equation, Integral Transform Methods, Inhomogeneous PDE Problems with Green's Functions Approach.

14.21.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Solve first-order and higher-order ordinary differential equations using various analytical methods, and determine the existence and uniqueness of solutions for initial value problems	PO1, PO2	C1, C2, C3	Lectures Discussions Handouts, Power Point Slides, Exercise	Incourse, Final Exam
CO2	Apply techniques to solve second-order ODEs, and utilize series solutions to address special functions such as Legendre polynomials and Bessel functions	PO1, PO2, PO4	C3, C4, P4	Lectures Discussions, Power Point Slides, Exercise	Quiz, Assignment Final Exam
CO3	Analyze and solve partial differential equations (PDEs) using methods like separation of variables, integral transforms, and Green's functions, and apply these solutions to practical	PO1, PO2, PO3, PO5	C4, C5	Lectures Discussions, Power Point Slides, Exercise	Incourse Assignment, Final Exam

	engineering scenarios				

14.21.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓						✓	✓	✓				✓		✓		✓	✓

14.21.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	First-order ODE: General Form of Solution, First-degree First-order Equations, Separable-variable Equations, Exact Equations, Inexact Equations	CO1
2	3-4	Inexact Equations, Integrating Factors, Linear Equations, Homogeneous Equations, Isobaric Equations	CO1
3-4	5-8	Bernoulli's Equation, Existence and Uniqueness of Solutions for Initial Value Problems, Higher-Degree First-Order Equations, Clairaut's Equation.	CO2
5-6	9-12	Second-Order ODEs: Homogeneous Linear ODEs of Second Order, Homogeneous Linear ODEs with Constant Coefficient, Euler–Cauchy Equations	CO2
7	13-14	Existence and Uniqueness of Solutions, Wronskian, Nonhomogeneous ODEs, Method of Undetermined Coefficients, Solution by Variation of Parameters.	CO2
8-10	15-20	Series Solutions of ODEs: Power Series Method, Legendre's Equation and Legendre Polynomials, Bessel's Equation and Bessel Functions, Laguerre Differential Equation and Laguerre Polynomials, Airy Differential Equation, Hermite Differential Equation and Hermite Differential Polynomials.	CO2
11	21-22	Partial Differential Equations (PDEs) Important Partial Differential Equations: The Wave Equation, The Diffusion Equation	CO3
12	23-24	Laplace Equation, Poisson's Equations, Schrodinger's Equation, Solving PDEs: General and Particular Solutions, Separation of Variables.	CO3
13-14	25-28	Superposition of Separated Solutions, Separation of Variables in Polar Coordinates. Laplace Equation in Polar Coordinates, Spherical Harmonics, Helmholtz's Equation, Integral Transform Methods, Inhomogeneous PDE Problems with Green's Functions Approach.	CO3

14.21.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.21.8 Text Books and Reference Books

1) Mathematical Methods for Physics and Engineering, 3rd Edition, K. F. Riley, M. P. Hobson, and S. J. Bence, Cambridge University Press.

2) Advanced Engineering Mathematics, 10th Edition, Erwin Kreyszigm Herbert Kreyszig and Edward J. Norminton, John-Wiley and Sons.

3) Mathematical Method for Physicist, 6th Edition, George B. Arfken and Hans J. Weber, Elsevier Academic Press.

4) Schaum's Outline of Advanced Mathematics for Engineers and Scientists, 1st Edition, Murray R. Spiegel, McGraw Hill.

5) Schaum's Outline of Differential Equations, 4th Edition, Richard Bronson and Gabriel Costa, McGraw Hill.

6) Schaum's Outline of Partial Differential Equations, 3rd Edition, Paul Du Chateau and D. W. Zachmann, McGraw Hill.

7) A First Course in Differential Equations with Modeling Applications, 10th Edition, Dennis G. Zill.

14.22 Circuit Simulation Laboratory

14.22.1 Introduction of the Course

Course Code and Title: 0714-EEE-2102: Circuit Simulation Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This laboratory focuses on circuits with electrical and electronic components for rectification, filtering, regulation, amplification, etc. providing a structured environment for students to develop essential skills and understanding.

Through hands-on experimentation, problem-solving, and visualization of circuit behavior, students gain proficiency in circuit analysis and design.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0713-EEE-1102: Electrical Circuit Analysis Laboratory.

14.22.2 Course Objectives

The students are expected to

1) Understand the behavior of discrete electronic components and electronic devices such as capacitors, inductors, diodes, and transistors.

2) Develop skills to use circuit simulation tools for analyzing circuit behavior before implementing them in real life.

3) Gain expertise in modeling circuits using non-linear components.

14.22.3 Course Content

Experiments in relevance with the 0714-EEE-2101: Analog Electronic I course.

Projects related to 0714-EEE-2101: Analog Electronic I course contents to achieve specific program outcomes.

14.22.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate competence in using circuit simulation techniques to build, test, analyze, and verify analog circuits, as well as troubleshoot circuit problems.	PO2, PO3	C3, A1, A2	Lectures, Simulation, Experiment	Lab reports, Lab tests, Viva
CO2	Design various electronic circuits for applications such as rectification, regulation, amplification, filtering	PO2, PO3	C3, C4	Lectures, Simulation, Experiment	Lab reports, Lab tests, Viva
CO3	Analyze the behavior of electronic components to	PO1	C4	Lectures, Simulation, Experiment	Lab reports, Lab tests, Viva

	understand their characteristics				
CO4	Design, and execute a project that demonstrates the application of electrical and electronic circuits to a real-world problem.	PO3, PO5, PO9	C6, A4	Project	Project report, Presentation, Viva, Quiz

14.22.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓		✓	✓			✓	✓						✓	✓		✓	

14.22.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction to the simulation software.	CO1
2	Experiment 01	Simulation of R-C filter.	CO1, CO2
3	Experiment 02	Simulation of diode I-V characteristic.	CO1, CO3
4	Experiment 03	Simulation of half wave rectifier circuit using diodes.	CO1, CO2
5	Experiment 04	Simulation of full wave rectifier using diodes with and without filter capacitor.	CO1, CO2
6	Experiment 05	Simulation of Zener diode circuit.	CO1, CO3
7	Experiment 06	Simulation of positive and negative clipping circuits using diodes with bias voltage.	CO1, CO2
8	Experiment 07	Simulation of positive and negative clamping circuits using diodes.	CO1, CO2
9	Experiment 08	Simulation of INPUT-OUTPUT characteristics of BJT common emitter configuration.	CO1, CO2
10	Experiment 09	Simulation of common emitter voltage amplifier circuit with voltage divider bias and calculation of voltage gain and frequency response.	CO1, CO2

11	Experiment 10	Simulation of common Emitter L-C-R parallel tuned circuit.	CO1, CO2
12	Experiment 11	Simulation of DC adapter using center tap transformer.	CO1, CO2
13	Project	Demonstration of a project using the components used throughout the course.	CO4
14	Lab Test	Laboratory assessment of the carried-out experiments.	CO1, CO2, CO3

14.22.7 Assessment Pattern/ Strategy

Assessment will be based on the successful simulation and analysis of different circuits using designated software, accurate documentation and interpretation of laboratory experiment results, completion of a comprehensive final project demonstrating circuit design skills, and performance in class activities.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.22.8 Text Books and Reference Books

1) Electronic Devices and Circuits, 5th Edition, David Bell, Oxford University Press.

2) Electronic Devices and Circuit Theory, Paperback Edition, R. Boylestad and L. Nashelsky, Pearson.

3) Microelectronic Circuits: Theory and Applications, 7th Edition, Adel S. Sedra, Kenneth C. Smith and Arun N. Chandorkar, Oxford University Press.

14.23 Digital Electronics Laboratory

14.23.1 Introduction of the Course

Course Code and Title: 0714-EEE-2104: Digital Electronics Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: Students will learn the fundamentals of digital logic levels and how to use them to build digital electronics circuits by participating in the Digital Electronics Lab. Students who complete this course will be equipped to analyze and construct a variety of digital electrical circuits.

Prerequisites (if any): No prerequisite.

14.23.2 Course Objectives

The students are expected to

1) Thoroughly understand the fundamental concepts and techniques used in digital electronics.

2) Analyze and design various combinational and sequential circuits in this lab.

3) Gain expertise in modeling circuits using digital electronic ICs.

14.23.3 Course Content

Experiments in relevance with the EEE 2103 Digital Electronics course.

Projects related to EEE 2103 Digital Electronics course contents to achieve specific program outcomes.

14.23.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Identify the various digital ICs and understand their operation	PO1, PO5	C1, C2	Lectures, Simulation, Experiment	Lab reports, Hardware demonstrati on
CO2	Understand the function of elementary digital circuits, adders etc. under real and simulated environments	PO1, PO2	C1, C3	Lectures, Simulation, Experiment	Lab reports, Hardware demonstrati on
CO3	Design and test combinational circuits	PO1, PO2	C1, C3, C4	Lectures, Simulation, Experiment	Lab reports, Hardware demonstrati on
CO4	Design and develop sequential circuits	PO1, PO2	C1, C3, C4	Lectures, Simulation, Experiment	Lab reports, Hardware demonstrati on
CO5	Demonstrate team-based laboratory activities with fellow students to interact effectively on a social and	PO8, PO9, PO10, PO12	P2, P6	Group discussion, Project	Project report, Presentatio n, Viva, Quiz

	interpersonal level				

14.23.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓				✓	✓			✓				✓		✓

14.23.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Basic knowledge on logic gate implementation and get familiar with IC.	CO1
2-3	Experiment 01	Construct and verify the operations of basic gates (AND, OR, NOT) using analog components (Transistors and Diodes).	CO1, CO2
4	Experiments 02	Simplification and circuit realization of an arbitrary Boolean expression using K-map	CO2
5-6	Experiments 03, 04	Design and implement Half Adder and Full Adder circuits using basic logic gates, and BCD adder.	CO2
7-9	Experiments 05, 06	Design and construct sequential circuits like S-R and J-K, D, and T flip-flop using basic components and ICs.	CO4
10-11	Experiments 07, 08	Design and construct counter circuits.	CO4
12	Experiments 09, 10	Design and construct combinational circuits.	CO3
13	Project demonstration	Use multimedia and necessary documentation to communicate the project	CO5
14	Final Exam	Construct a circuit for a given problem based on the knowledge of the course.	CO1-CO4

14.23.7 Assessment Pattern/ Strategy

Assessment will be based on their successful completion of all experiments and reports. The students will be continuously assessed weekly based on their responsiveness to the instructor's questions about the experiments. The final exam will assess their ability to construct and test a given circuit followed by viva.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%

Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.23.7 Text Books and Reference Books

1) Digital Systems, 12th Edition, Ronald Tocci, Neal Widmer and Greg Moss, Pearson.

2) Digital Fundamentals, 11th Edition, Thomas L. Floyd, Pearson.

14.24 Analog Electronics II

14.24.1 Introduction of the Course

Course Code and Title: 0714-EEE-2201: Analog Electronics II.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Electronics are inseparably linked with modern civilization. So it is very important for engineers, in this field, to have proper knowledge of electronics. The main objective of this course is to provide students with the advanced theory and application of electronics. General theory of electronics is discussed in Electronics I course. Hence, to discuss in detail the working process, design, usage of more advanced and complex electronic circuits like operational amplifier, feedback amplifier, power amplifier, oscillator circuit etc. is the aim of this course. The effects of changes in signal frequency, temperature, loads etc. on various circuits are also included in this course so that students can apply the knowledge to solve various practical problems.

Prerequisites (if any): 0714-EEE-2101: Analog Electronics I.

14.24.2 Course Objectives

The students are expected to

1) Know about advanced electronic circuits.

2) Know how to analyze and find final output response of electronic circuits.

3) Apply the knowledge of electronics in solving/designing electronics related problems/requirement in home and industries.

14.24.3 Course Content

Operational Amplifiers (Op-Amp): Differential Amplifier-Voltage Gain, Input Impedance and Output Impedance, CMRR, Basic Construction of Op-Amp, Different Parameters of Op-Amp, Properties of Ideal Op-Amps, Frequency Response of an Op-Amp, Inverting and Non-Inverting Amplifier, Summing and Difference Amplifier, Current-to-Voltage Converter, Voltage Follower, Differentiator, Integrator, Op-Amp Comparator, Op-Amp Schmitt-Trigger Circuit, Multivibrators using Op-Amp, Precision Rectifier and Other Applications, Active Filters- Different Types of Filters and Specifications, Transfer Functions, Design and Construction of First and Second Order Low, High and Band Pass Filters using Op-Amps.

Oscillators: Basic Principle of Oscillator, Bark-Hausen Criterion for Oscillation, Phase Shift Oscillators, Wein Bridge Oscillator, Bridge-Tuned Twin T Oscillator, LC Oscillators–

Hartley and Colpitts, Negative Resistance Oscillator, Crystal Oscillator, Frequency Stability.

Power and Tuned Amplifiers: Class A, Class B, Class AB Power Amplifier, Transformer-Coupled Class A Amplifier, Push-Pull Amplifier, Complementary Symmetry, Quasi-Complementary, Class-D Amplifier, Tuned Amplifier, Single Tuned Amplifier, Double Tuned Amplifier, Stagger Tuned Amplifier.

Pulse and Switching Circuits: Classification of Multivibrator, Astable, Monostable, Bistable Multivibrator with BJT, 555 Timer IC, Astable, Monostable, Bistable Multivibrator with 555 IC, Bistable Triggering Problem, Schmitt Trigger with BJT, Blocking Oscillators, Voltage and Time Base Generators, Exponential Sweep Circuits, Constant Current Charging Circuit, Sweep Circuit for TV Receivers, Pulse Transformer.

Voltage Regulators: Series and Shunt Regulations, Methods to Improve the Regulators, IC Voltage Regulators, Switching Regulators.

Phase Locked Loops: Basic PLL, Major Building Blocks, Lock and Capture Range, Applications of PLL, FM Demodulation, FSK Demodulation, AM Demodulation, Frequency Synthesizer.

14.24.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Memorize/ recognize/ understand advanced electronics circuits	PO1	C1, C2	Lectures Discussions Handouts	Assignment Incourse Final Exam
CO2	Analyze/examine advanced electronics circuits and find their output performance	PO2	C4	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO3	Design/develop efficient circuits/systems to optimize their performance	PO3	C6	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO4	Apply the knowledge in solving/design electronics circuit related problems in homes and industries	PO4	C3	Discussions Exercise	Assignment Presentation

14.24.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓	✓	✓			✓	✓					✓	✓	✓	✓		

14.24.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-3	1-6	Differential Amplifier-Voltage Gain, Input Impedance and Output Impedance, CMRR, Basic Construction of Op-Amp, Different Parameters of Op-Amp, Properties of Ideal Op-Amps, Frequency Response of an Op-Amp, Inverting and Non-Inverting Amplifier, Summing and Difference Amplifier, Current-to-Voltage Converter, Voltage Follower, Differentiator, Integrator, Op-Amp Comparator, Op-Amp Schmitt-Trigger Circuit, Multivibrators using Op-Amp, Precision Rectifier and Other Applications, Active Filters-Different Types of Filters and Specifications, Transfer Functions, Design and Construction of First and Second Order Low, High and Band Pass Filters using Op-Amps.	CO1 CO2 CO3 CO4
4-5	7-10	Basic Principle of Oscillator, Bark-Hausen Criterion for Oscillation, Phase Shift Oscillators, Wein Bridge Oscillator, Bridge-Tuned Twin T Oscillator, LC Oscillators– Hartley and Colpitts, Negative Resistance Oscillator, Crystal Oscillator, Frequency Stability.	CO1 CO2 CO3 CO4
6-7	11-14	Class A, Class B, Class AB Power Amplifier, Transformer-Coupled Class A Amplifier, Push-Pull Amplifier, Complementary Symmetry, Quasi-Complementary, Class-D Amplifier, Tuned Amplifier, Single Tuned Amplifier, Double Tuned Amplifier, Stagger Tuned Amplifier.	CO2 CO3 CO4
8-10	15-20	Classification of Multivibrator, Astable, Monostable, Bistable Multivibrator with BJT, 555 Timer IC, Astable, Monostable, Bistable Multivibrator with 555 IC, Bistable Triggering Problem, Schmitt Trigger with BJT, Blocking Oscillators, Voltage and Time Base Generators, Exponential Sweep Circuits, Constant Current Charging Circuit, Sweep Circuit for TV Receivers, Pulse Transformer.	CO1 CO2 CO3
11-12	21-24	Series and Shunt Regulations, Methods to Improve the Regulators, IC Voltage Regulators, Switching Regulators.	CO3 CO4
13-14	25-28	Basic PLL, Major Building Blocks, Lock and Capture Range, Applications of PLL, FM Demodulation, FSK Demodulation, AM Demodulation, Frequency Synthesizer.	CO1 CO3 CO4

14.24.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Will be given in convenient time

3) Incourse: There will be minimum one incourse exam; if two or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.24.8 Text Books and Reference Books

1) Op-amps and Linear Integrated Circuit Technology, 2nd Edition, Ramakant A Gayakwad, Prentice-Hall.

2. Solid State Pulse Circuits, David A. Bell, Oxford University Press.

3. Operational Amplifiers and Linear Integrated Circuits, 6th Edition, Robert F. Coughlin and Frederick F. Driscoll, Pearson.

4. Op Amps for Everyone, 4th Edition, Bruce Carter, Newnes.

5. Electronic Devices and Circuit Theory, Paperback Edition, R. Boylestad and L. Nashelsky, Pearson.

6. Electronic Circuits: Discrete and Integrated, Paperback Edition, Donald Schilling, Charles Belove, and Raymond Saccardi, McGraw Hill.

7. Microelectronics, 2nd Edition, Jacob Millman and Arvin Grabel, Tata McGraw Hill.

8. Microelectronic Circuits: Theory and Applications, 7th Edition, Adel S. Sedra, Kenneth C. Smith and Arun N. Chandorkar, Oxford University Press.

9. Electronic Principles, Paperback Edition, Albert Malvino and David Bates, McGraw Hill.

14.25 Electromechanical Energy Conversion II

14.25.1 Introduction of the Course

Course Code and Title: 0713-EEE-2203: Electromechanical Energy Conversion II.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to fulfill the knowledge of electrical machines of bachelor students. For an electrical engineer, it is very important to know how to generate electrical energy. In this course, the students will be familiarized with synchronous generator, synchronous motor, three phase induction motor and single phase induction motor. The major portion of electrical energy used in todays is generating by synchronous generator.

Prerequisites (if any): 0713-EEE-2107: Electromechanical Energy Conversion I.

14.25.2 Course Objectives

The students are expected to

1) Understand the principles of synchronous motor and synchronous generator. Get a clear concept about their construction. Differentiate between synchronous motor and synchronous generator. Explain different characteristics of synchronous generator.

2) Realize the power flow in synchronous motor. Develop a clear concept about the methods of starting synchronous motor. Represent synchronous motor V-Curve and inverted V-Curve.

3) Analyze the performance of three phase and single phase induction motor. Understand torque-slip characteristics, equivalent circuit diagram and phasor diagram.

4) Develop a basic idea about the starting and speed control methods of three phase and single phase induction motor.

5) Develop the capability to conduct experiments on single and three phase electric machines.

14.25.3 Course Content

Synchronous Generators: General Aspects and Principles of Synchronous Machines, Generator and Motor Action, Alternating EMF, Relation between Frequency, Speed and Number of Poles, Constructional Features of Synchronous Machines, Excitation Systems, Armature Winding, Two and Three Phase Rotating Magnetic Field, Armature Resistance, Leakage Reactance and Armature Reaction, Equivalent Circuit and Phasor Diagram, Voltage Regulation, Losses and Efficiencies in Synchronous Generators, Parallel Operation of Alternators, Synchronizing Single and Three Phase Alternators and Synchronising Current, Power and Torque.

Synchronous Motors: Construction, Working Principle and Equivalent Circuit of a Synchronous Motor, Phasor Diagram, Relation between Supply and Excitation Voltage, Torques in a Synchronous Motor, Power Flow in Synchronous Motor, Salient-pole Synchronous Motor, V- Curve and Inverted V-Curve, Effect of Load and Excitation Change, Methods of Starting Synchronous Motor, Synchronous Condenser, Hunting and Applications of Synchronous Motors.

Three-Phase Induction Motors: Constructional and Operational Principle, Production of Revolving Field, Reversal of Direction of Rotation, Slip, Speed of Rotor Field, Rotor EMF, Resistance, Reactance, Impedance, Current and Power Factor, Rotor Equivalent Circuit, Stator Parameters, Induction Motor on No-load and on Load, Constant and Variable Losses, Power Flow, Rotor Efficiency, Torque Development, Effect of Load and Voltage on Torque, Torque-Slip Curve, Stator Resistance, Voltage-Ratio Test, No-load Test, Blocked Rotor Test.

Starting and Speed Control Methods: Squirrel Cage Induction Motors, Slip-Ring Induction Motors, Starting Methods of Squirrel Cage Induction Motors, Direct on Line (D.O.L.) Starter, Stator Resistance (or Reactance) Starter, Star-Delta Starter, Auto-Transformer Starter, Rotor Resistance Starter for Slip Ring Induction Motor, Speed Control by

Changing the Slip, Rotor Circuit Resistance, Supply Voltage, Voltage in the Rotor Circuit, Supply Frequency, Changing the Poles, and Rotor EMF Injection.

Single-Phase Induction Motor: Classification of Single-Phase Motors, Single- Phase Induction Motors, Torque and Field in Single-Phase Induction Motors, Equivalent Circuit, Methods of Self-Starting.

Special Machines: DC Servomotors, Brushless DC Motors, Brushless Synchronous Generator, Brushless Synchronous Motor, Stepper Motors: Permanent Magnet and Variable Reluctance Type.

14.25.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the construction and basic operation principles of synchronous machine and induction motor	PO1	C1	Lectures, Interactive discussions, Video tutorials	Incourse exam, Final exam
CO2	Develop and analyze the electrical equivalent circuit diagrams and phasor diagrams of synchronous machines and induction motor	PO2	C2, C4	Lectures, Interactive discussions	Incourse exam, Final exam
CO3	Calculate power losses and estimate efficiencies and solve related mathematical problems for synchronous machines and induction motors	PO2, PO4	C3	Lectures, Interactive discussions, Problem solving	Assignment, Incourse exam, Final exam
CO4	Investigate and interpret the characteristics and	PO4	C4	Lectures, Interactive discussions,	Incourse exam, Final exam

	performance parameters of synchronous machine and induction motor				
CO5	Design and evaluate connection diagrams for the safe starting and operation of three phase and single phase induction motor.	PO3	C5, C6	Lectures, Interactive discussions, Problem solving	Assignment, Incourse exam, Final exam

14.25.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓		✓	✓			✓	✓						✓	✓			

14.25.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	General aspects and principles of synchronous machines, alternating emf, relation between frequency, speed and number of poles, constructional features of synchronous machines,	CO1
2	3-4	Excitation systems, armature winding, two and three phase rotating magnetic field, armature resistance, leakage reactance and armature reaction, equivalent circuit and phasor diagram, voltage regulation, OCC and SCC of Synchronous generator.	CO2, CO4
3	5-6	Losses and efficiencies in synchronous generators, parallel operation of alternators, synchronizing single and three phase alternators, power and torque.	CO3
4	7-8	Working principle and equivalent circuit of a synchronous motor, phasor diagram, relation between supply and excitation voltage, torques in a synchronous motor.	CO1, CO2
5-6	9-12	Power flow and losses in synchronous motor, Salient-pole synchronous motor, v- curve and inverted v-curve, effect of load and excitation change, methods of starting synchronous motor, synchronous condenser, hunting and applications of synchronous motors.	CO3

7-8	13-16	Constructional and operational principle of three phase induction motor, production of revolving field, reversal of direction of rotation, slip, speed of rotor field, rotor emf, resistance, reactance, impedance, current and power factor, rotor equivalent circuit, stator parameters.	CO1, CO2
9-10	17-20	Induction motor on no-load and on load, constant and variable losses, power flow, rotor efficiency, torque development, effect of load and voltage on torque, torque-slip curve, stator resistance, voltage-ratio test, no-load test, blocked rotor test.	CO3, CO4
11	21-22	Types of induction motor, starting methods of squirrel cage induction motors, direct on line (d.o.l.) starter, stator resistance (or reactance) starter, star-delta starter, auto-transformer starter, rotor resistance starter for slip ring induction motor, speed control by changing the slip, rotor circuit resistance, supply voltage, voltage in the rotor circuit, supply frequency, changing the poles, and rotor emf injection.	CO5
12-13	23-26	Classification of single-phase induction motors, torque and field in single-phase induction motors, equivalent circuit, methods of self-starting.	CO1, CO2
14	27-28	DC servomotors, brushless dc motors, brushless synchronous generator, brushless synchronous motor, stepper motors: permanent magnet and variable reluctance type.	CO1

14.25.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 assignment; if 2 or more assignments are taken then their average will be considered in final evaluation.

3) Incourse Exam: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.25.8 Text Books and Reference Books

1) Electrical Machines, 1st Edition, S. K. Sahdev, Cambridge University Press.

2) Electric Machinery Fundamentals, 5th Edition, Stephen J. Chapman, McGraw-Hill Education.

3) Electric Machinery, 6th Edition, A.E. Fitzgerald, Charles Kingsley, JR and Stephen D. Uman, McGraw-Hills.

4) Electric Machines: Theory, Operating Applications, and Controls, 2nd Edition, Charles I. Hubert, Pearson.

5) A Text Book of Electrical Technology, Volume II, AC & DC Machines, B.L. Thereja, A.K. Thereja, 23rd Edition.

14.26 Fundamentals of Mechanical Engineering

14.26.1 Introduction of the Course

Course Code and Title: 0715-MEC-2205: Fundamentals of Mechanical Engineering.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The Fundamentals of Mechanical Engineering course is designed to provide electrical and electronic engineering students with a comprehensive understanding of essential mechanical engineering principles. This course serves as a crucial bridge between electrical and mechanical disciplines, enabling students to grasp the interdisciplinary nature of modern engineering challenges. By covering topics such as thermodynamics, heat transfer, fluid mechanics, and mechanical properties of materials, students will develop a solid foundation in mechanical concepts that are often encountered in electrical engineering applications. This knowledge will enhance their ability to design, analyze, and optimize systems that involve both electrical and mechanical components, preparing them for the complex, multidisciplinary nature of real-world engineering projects.

Prerequisites (if any): No prerequisite.

14.26.2 Course Objectives

The students are expected to

1) Understand the fundamental concepts of heat transfer, thermodynamics, and fluid mechanics, including the laws of thermodynamics, heat transfer mechanisms, and fluid flow principles.

2) Analyze and apply thermodynamic processes, cycles, and systems, including refrigeration and air-conditioning systems, with a focus on energy conversion and efficiency.

3) Comprehend the mechanical properties of materials, including stress-strain relationships, elasticity, and material testing methods, and their applications in engineering design.

4) Examine the principles and components of various mechanical engines, including steam engines, internal combustion engines, and gas turbine engines.

5) Develop problem-solving skills in thermal systems, fluid mechanics, and mechanical design by applying theoretical knowledge to practical engineering scenarios.

14.26.3 Course Content

Heat: The Concept of Heat, Heat Transfer: Conduction, Convection and Radiation, Concept of Temperature, Thermal Equilibrium, Micro and Macro State, Boltzmann Factor, Energy Transfer by Work and Heat.

Thermodynamics: Laws of Thermodynamics: Zeroth, First, Second and Third Law of Thermodynamics, The Carnot Engine, Carnot's Theorem, Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Function, Gibbs Function, Maxwell's Relations, The Chemical Potential, Shannon Entropy and Information, Thermodynamic Processes: Isothermal and Adiabatic, Reversible and Irreversible Processes.

Refrigeration: The Performance of Refrigeration Systems, The Theoretical Single-Stage Compression Cycle, Refrigerants, Refrigeration Equipment Components, The Real Single-Stage Cycle, Absorption Refrigeration.

Air-Conditioning: The Complete System, System Selection and Arrangement, HVAC Components and Distribution Systems, Types of All-Air Systems, Air-and- Water Systems, All-Water Systems, Decentralized Cooling and Heating, Heat Pump Systems, Heat Recovery Systems, Thermal Energy Storage.

Fluid Mechanics: Introduction to Fluid Flow, Pathlines, Streamlines and Streaklines, Angular Velocity, Vorticity, and Strain, Circulation, Stream Function, Velocity Potential, Inviscid and Incompressible Flow: Bernoulli's Equation, Condition on Velocity for Incompressible Flow, Inviscid and Compressible Flow: Governing Equation and Condition for Total Stagnation, Viscous Flow: Navier-Stokes Theorem.

Mechanical Properties of Solids: Stress and Strain, Elasticity, Stress–Strain Curves, Torsion Test, Bend Test, Hardness Test, Slip and Crystallographic Textures, Dislocation Geometry and Energy, Mechanical Properties of Engineering Material: Tensile Strength, Hardness, Fatigue, Impact Strength, Creep.

Mechanical Engines: Stream Engines, Internal Combustion Engines, Gas Turbine Engines.

14.26.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain and apply fundamental concepts of heat transfer, thermodynamics and fluid mechanics	PO1, PO2	C1, C3, A1	Lectures, Problem-solving sessions, Demonstration	Assignment Presentation, Final Exam
CO2	Analyze and design thermodynamic processes, cycles, and systems, including	PO3, PO4	C1, C6, A1, A3	Lectures, Case studies, Design project	Incourse and Final Exam

	refrigeration and air-conditioning				
CO3	Evaluate mechanical properties of materials and their applications in engineering design	PO1, PO3	C1,C3,C6, A1, A2	Lectures, Laboratory experiments, Material testing demonstration	Assignment, Final Exam
CO4	Examine and compare various types of mechanical engines and their operating principles	PO1, PO2, PO4	C1, C4, C6, A1	Lectures, Video demonstration, Field visits	Incourse, Final Exam
CO5	Solve complex problems in thermal systems, fluid mechanics, and mechanical design by applying theoretical knowledge to practical scenarios	PO2, PO3, PO5	C4, C6, A1, A5	Problem-based learning, Group projects, Computational simulations	Technical Report, Final Exam

14.26.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓		✓

14.26.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Mechanical Engineering	CO1
2-3	3-6	Fundamentals of Thermodynamics	CO1
4-5	7-10	Laws of Thermodynamics	CO2
6	11-12	Thermodynamic Potentials	CO2

7	13-14	Thermodynamic Processes	CO2
8	15-16	Heat Transfer	CO1
9	17-18	Internal Combustion Engines	CO3, CO4
10	19-20	Refrigeration systems	CO2, CO5
11	21-22	Air Conditioning systems	CO2, CO5
12	23-24	Fluid Mechanics	CO5
13	25-26	Mechanical Properties of Solids	CO3
14	27-28	Energy Conversion and Power Generation	CO4, CO5

14.26.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation on the Technical Report or project.

Besides presentation, 1 Technical Report is required to submit related to the design of thermal systems.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.26.8 Text Books and Reference Books

1) Concepts in Thermal Physics, 2nd Edition, Stephen J. Blundell and Katherine M. Blundell, Oxford University Press.

2) Thermodynamics: An Engineering Approach, 8th Edition, Yunus A. Cengel Dr and Michael A. Boles, McGraw Hill Education.

3) Thermal Physics, 2nd Edition, Charles Kittel and HerbertKroemer, W. H. Freeman Publication.

4) An Introduction to Thermal Physics, 1st Edition, Daniel V. Schroeder, Pearson.

5) Heating, Ventilating, and Air Conditioning Analysis and Design, 6th Edition, Faye C.

McQuiston, Jerald D. Parker and Jeffrey D. Spitler, John-Wiley & Sons, Inc.

6) Fundamentals of Aerodynamics, 6th Edition, John D. Anderson, Jr., McGraw-Hill Education.

7) Mechanical Behavior of Materials, 2nd Edition, William F. Hosford, Cambridge University Press.

14.27 Probability and Statistics

14.27.1 Introduction of the Course

Course Code and Title: 0542-STA-2207: Probability and Statistics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students a comprehensive understanding of statistical methods and probabilistic reasoning. Modern engineering problems often involve complex data and uncertainty, emphasizing the need to develop experts skilled in data analysis and informed decision-making. This course equips students with the tools to model and interpret data, assess risks, and apply probabilistic techniques to engineering applications, thereby enhancing their problem-solving capabilities and preparing them for professional practice in engineering.

Prerequisites (if any): No prerequisite.

14.27.2 Course Objectives

The students are expected to

1) Comprehend the basic principles of probability and statistics to build a strong foundational knowledge.

2) Learn to apply key probability theorems in solving real-world engineering problems.

3) Identify and explore various probability distributions and their applications in engineering scenarios.

4) Develop the ability to perform statistical inferences concerning means, variances, and proportions, enabling them to make data-driven decisions and test hypotheses in engineering contexts.

5) Gain proficiency in regression analysis and analysis of variance techniques, allowing them to model relationships between variables and evaluate experimental data effectively.

14.27.3 Course Content

Introduction: Modern Statistics, Statistics and Engineering.

Probability: Sample Spaces and Events, Counting, The Axioms of Probability, Theorems of Probability, Conditional Probability, Baye’s Theorem, Mathematical Expectation and Decision Making.

Probability Distributions: Random Variables, The Binomial Distribution, The Hypergeometric Distribution, The Mean and Variance of a Probability Distribution, Chebyshev’s Theorem, The Poisson approximation to the Binomial Distribution, Poisson Processes, The Geometric Distribution, The Multinomial Distribution.

Probability Densities: Continuous Random Variables, The Normal Distribution, The Normal Approximation to the Binomial Distribution, The Uniform Distribution, The Weibull Distribution, Joint Probability Densities.

Treatment of Data: Frequency Distributions, Graphs of Frequency Distributions, Stem-and-Leaf Plots, Descriptive Measures.

Sampling Distributions: Population and Samples, The Sampling Distribution of the Mean (known), The Sampling Distribution of the Mean (unknown), The Sampling Distribution of Variance.

Inferences Concerning Means: Point Estimation, Tests of Hypotheses, Null Hypotheses and Significance Tests, Hypotheses Concerning One Mean, Operating Characteristic Curves, Hypotheses Concerning Two Means.

Inferences Concerning Variances: The Estimation of Variances, Hypotheses Concerning One Variance, Hypotheses Concerning Two Variances.

Inferences Concerning Proportions: Estimation of Proportions, Bayesian Estimations, Hypotheses Concerning One Proportion, Hypotheses Concerning Two Proportions, The Analysis of $r \times c$ Tables, Goodness of Fit.

Nonparametric Tests: The Sign Test, Test of Randomness, The Rank-Sum Tests.

Regression Analysis: The Method of Least Squares, Inferences Based on Least Square Estimators, Multiple Regression, Correlation.

Analysis of Variance: General Principles, Completely Randomized Designs, Randomized Block Designs, Multiple Comparisons.

Factorial Experiments: Two-Factor Experiments, Multifactor Experiments, 2^{nd} Factorial Experiments, Confounding in a 2^{nd} Factorial Experiment, Fractional Replication.

14.27.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a thorough understanding of fundamental concepts in probability and statistics	PO1	C1, C2	Lectures Discussions Handouts Exercise	Incourse Final Exam
CO2	Analyze and interpret various probability distributions and utilize these distributions in practical	PO1, PO2, PO4	C3, C4, C5	Lectures Discussions Exercise	Assignment Final Exam

	engineering applications				
CO3	Perform statistical inferences on means, variances, and proportions, using appropriate techniques to test hypotheses and make data-driven decisions	PO2, PO4, PO5	C3, C4, C5, P4	Lectures Discussions Exercise	Assignment Final Exam
CO4	Utilize regression analysis and analysis of variance techniques to model relationships between variables, design experiments, and analyze experimental data effectively in engineering applications	PO3, PO4, PO5	C3, C5, C6, P4	Lectures Discussions Exercise	Incourse Final Exam

14.27.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓						✓		✓	✓				✓			✓	✓

14.27.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-3	Modern Statistics, Statistics and Engineering, Frequency Distributions, Graphs of Frequency Distributions, Stem-and-Leaf Plots, Descriptive Measures.	CO1
2-3	4-6	Sample Spaces and Events, Counting, The Axioms of Probability, Theorems of Probability, Conditional Probability, Baye's Theorem.	CO1, CO2
4-6	7-11	Mathematical Expectation and Decision Making, Random Variables, The Binomial Distribution, The Hypergeometric	CO2

		Distribution, The Mean and Variance of a Probability Distribution, Chebyshev's Theorem, The Poisson approximation to the Binomial Distribution, Poisson Processes, The Geometric Distribution, The Multinomial Distribution.	
6-7	12-14	Probability Densities: Continuous Random Variables, The Normal Distribution, The Normal Approximation to the Binomial Distribution, The Uniform Distribution, The Weibull Distribution, Joint Probability Densities.	CO2
8	15-16	Regression Analysis: The Method of Least Squares, Inferences Based on Least Square Estimators, Multiple Regression, Correlation.	CO4
9	17-18	Population and Samples, The Sampling Distribution of the Mean (known), The Sampling Distribution of the Mean (unknown), The Sampling Distribution of Variance.	CO3
10	19-20	Inferences Concerning Means: Point Estimation, Tests of Hypotheses, Null Hypotheses and Significance Tests, Hypotheses Concerning One Mean, Operating Characteristic Curves, Hypotheses Concerning Two Means.	CO3
11	21-22	Inferences Concerning Variances: The Estimation of Variances, Hypotheses Concerning One Variance, Hypotheses Concerning Two Variances. Inferences Concerning Proportions: Estimation of Proportions, Bayesian Estimations, Hypotheses Concerning One Proportion, Hypotheses Concerning Two Proportions	CO3
12	23-24	The Analysis of $r \times c$ Tables, Goodness of Fit. Nonparametric Tests: The Sign Test, Test of Randomness, The Rank-Sum Tests.	CO3
13-14	25-28	Analysis of Variance: General Principles, Completely Randomized Designs, Randomized Block Designs, Multiple Comparisons. Factorial Experiments: Two-Factor Experiments, Multifactor Experiments, 2^{nd} Factorial Experiments, Confounding in a 2^{nd} Factorial Experiment, Fractional Replication.	CO4

14.27.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.27.8 Text Books and Reference Books

1) Probability and Statistics for Engineers and Scientists, Hayter, Anthony J. (2012)

2) Probability and Statistics for Engineers, 9th Edition, by Irwin Miller and John Freund, Pearson.

3) Probability & Statistics for Engineers & Scientists, 9th Edition, Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, Pearson Education.

4) Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Sheldon M. Ross, Academic Press.

14.28 Fundamentals of Economics

14.28.1 Introduction of the Course

Course Code and Title: 0311-GED-2209: Fundamentals of Economics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students with a foundational understanding of economic principles and their application in real-world scenarios. It explores both microeconomic and macroeconomic concepts, enabling students to grasp the dynamics of individual and collective economic behavior. By examining topics like production, market systems, national income, fiscal policies, and global trade, the course prepares students to critically analyze economic challenges and opportunities. This knowledge is essential for making informed decisions, understanding policy-making processes, and appreciating the interconnectedness of local and global economies.

Prerequisites (if any): No prerequisite.

14.28.2 Course Objectives

The students are expected to

1) Familiarize themselves with the core vocabulary and concepts of microeconomics and macroeconomics.

2) Develop critical thinking skills to analyze economic data and evaluate economic arguments.

3) Foster an understanding of the role of economics in individuals' everyday lives, policy-making, and global trends.

4) Engage in thoughtful discussions on controversial economic issues and diverse perspectives.

14.28.3 Course Content

Introduction to Economics: The Central Economic Problem of Scarcity and Choice, Human Economic Behaviour, Opportunity Cost, Micro and Macro Economics, Factors of Production, Difference between Resource and Wealth, Free Goods and Economic Goods, Public and Private Goods, Different Economic Systems.

Types of Production: Primary, Secondary and Tertiary Production, The Market Economy: Elements of Demand and Supply, Causes of Changes in Demand and Supply, Elasticity of Demand and Supply, The Price Mechanism, Theory of Utility and Preferences, Consumer's Surplus, Theory of Production and Cost.

Theory of the Firm: Economies of Scale, Monopoly vs Competition, Private Enterprise: Definition and Objective, Types of Private Enterprise: Sole Traders, Partnerships, Joint Stock Companies, Holding Companies, Cooperatives, Public Enterprise: Definition, Nationalization, and Privatization.

The Circular Flow: National Income and Economic Growth, National Income Accounting, The Simple Keynesian Analysis of National Income, Savings, Investment, Fiscal Policy: Meaning, Taxation, Direct and Indirect Taxation.

Money and Banking: Definition of Money, Functions of Money, Characteristics of Good Monetary Medium.

Banks: Functions of Commercial Banks, Functions of Central Bank, International Trade: Advantages of International Trade, Terms of Trade, Methods of Protection, Balance of Payments, Exchange Rates, Balance of Payment Deficits and Surpluses, Role of IMF, GATT.

Economic Problem: Inflation, Economic Growth and Unemployment, Causes of Inflation, Instrument to Control Inflation.

14.28.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a basic understanding of fundamental concepts of economics	P02, PO11	C1, C2, C3	Lectures, Discussions, Group discussions, Handouts	Assignment Incourse Final Exam
CO2	Demonstrate understanding of basic concepts and theories of	P02, PO11	C1, C2, C3	Lectures, Discussions, Group discussions, Handouts	Assignment Incourse Final Exam

	consumer behavior				
CO3	Applying the key concepts and theories of economics in real life	P02, PO4, PO11	C3, C6, A4	Lectures, Discussions, Group discussions, Handouts	Assignment Incourse Final Exam
CO4	Applying the core theories in the context of Bangladesh	P02, PO4, PO7, PO11	C3, C6, A4, P7	Lectures, Discussions, Group discussions, Handouts	Assignment Incourse Final Exam
CO5	Enabling to apply macroeconomic theories to analyze and comprehend contemporary economic issues and events, fostering critical thinking and problem-solving skills in the context of the macroeconomy.	P02, PO4, PO7, PO11, PO12	C3, C6, A4, P7	Lectures, Discussions, Group discussions, Handouts	Assignment Incourse Final Exam

14.28.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
				✓		✓		✓	✓				✓		✓	✓			✓

14.28.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	What is economics? Scarcity, choice, and opportunity cost.	CO1
2-3	3-6	Supply and demand: Market equilibrium, price mechanisms.	CO1-CO3
4	7-8	Consumer behavior: Utility maximization, demand curves.	CO2-CO4
5-6	9-12	Producer behavior: Cost minimization, profit maximization, firm types.	CO2-CO4

7	13-14	Market structures: Perfect competition, monopoly, oligopoly, and externalities.	CO2-CO4
8	15-16	National Income	CO3-CO5
9-11	17-22	Monetary Systems	CO3-CO5
12	23-24	Inflation	CO3-CO5
13	25-26	The Open Economy	CO3-CO5
14	27-28	Unemployment and the Labor Market	CO3-CO5

14.28.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.28.8 Text Books and Reference Books

1) Mankiw, N. Gregory. Macroeconomics. 9th edition, Worth Publishers, 2016.

2) Perloff, Jeffrey M. Microeconomics. 8th edition, Pearson, 2018.

14.29 Analog Electronics Laboratory

14.29.1 Introduction of the Course

Course Code and Title: 0714-EEE-2202: Analog Electronics Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course is designed to provide practical experience in the characterization and analysis of analog electronic components and circuits, including

BJTs, MOSFETs, and operational amplifiers. It aims to reinforce theoretical knowledge through hands-on experiments, enabling students to understand the real-world applications and behavior of analog electronic devices.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis.

14.29.2 Course Objectives

The students are expected to

1) Equip themselves with the knowledge and skills to understand and characterize bipolar junction transistors (BJTs) in various configurations.

2) Provide hands-on experience in designing and analyzing both single-stage and multi-stage BJT amplifiers, with a focus on their frequency response.

3) Develop their ability to characterize and design MOSFET amplifiers and operational amplifiers, enabling them to apply these components in various practical applications.

14.29.3 Course Content

Experiments in relevance with the 0714-EEE-2101: Analog Electronic I and 0714-EEE-2201: Analog Electronic II courses.

14.29.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the characterization and behavior of bipolar junction transistors (BJTs) in various configurations	PO1, PO2	C1, C2, C3	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, Viva, Practical Exams
CO2	Design and analyze single-stage and multi-stage BJT amplifiers, including frequency response	PO2, PO3	C3, C4, C5	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, In-lab Assessments, Viva
CO3	Characterize and design MOSFET amplifiers and operational amplifiers for various applications	PO1, PO3, PO4	C3, C5, C6	Lectures, Demonstrations, Hands-on Lab Work	Lab reports, Viva, Practical Exams

14.29.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		

14.29.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1-2	Experiment 01	Bipolar Junction Transistor Characterization	CO1
3-4	Experiment 02	Single Stage BJT Amplifiers: Common Emitter	CO2
5-6	Experiment 03	Single Stage BJT Amplifiers: Common Collector and Common Base	CO2
7-8	Experiment 04	Frequency Response of the BJT amplifiers	CO2
9-10	Experiment 06	Multi-stage Amplifiers	CO2
11-12	Experiment 07	MOS Characterization and Amplifiers	CO3
12-14	Experiment 08	Operational Amplifiers	CO3

14.29.7 Assessment Pattern/ Strategy

Assessment will be based on multi-faceted approach to ensure students' grasp of theoretical concepts and their efficiency and accuracy in performing laboratory experiments related to analog electronics.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.29.8 Text Books and Reference Books

1) Fundamentals of Microelectronics by Behzad Razavi.

2) Microelectronic Circuits by Adel S. Sedra, Kenneth C. Smith.

14.30 Electromechanical Energy Conversion Laboratory

14.30.1 Introduction of the Course

Course Code and Title: 0713-EEE-2204: Electromechanical Energy Conversion Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: EEE is a field that involves working with various electrical machines such as transformers, motors, generators, and other equipment. This machine lab (Electromechanical Energy Conversion Laboratory) provides students with hands-on experience in handling and operating these machines, which enhances their practical understanding beyond theoretical knowledge gained in classrooms.

Prerequisites (if any): 0713-EEE-2107: Electromechanical Energy Conversion I.

14.30.2 Course Objectives

The students are expected to

1) Develop practical skills in assembling, testing, operating, and troubleshooting electrical machines (transformer, generator and motor) and equipment.

2) Equip with the capability to apply theoretical knowledge gained from classroom lectures in a practical setting.

3) Foster the ability to plan, conduct, and analyze experiments related to electrical machines.

4) Promote effective teamwork and communication skills through collaborative lab activities.

14.30.3 Course Content

Experiments in relevance with the 0713-EEE-2107: Electromechanical Energy Conversion I and 0713-EEE-2203 Electromechanical Energy Conversion II course.

14.30.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate proficiency in using laboratory tools to carry out experiments	PO1	C2	Lectures, Group discussion,	Quiz, Lab test, Viva,
CO2	Conduct experiments for analyzing of electrical machine performance	PO3	C3, A2	Lectures, Experiment	Lab reports, Hardware demonstration, Quiz, Lab test, Viva
CO3	Analyze different characteristics of machines	PO4	C4	Group discussion, Experiment	Lab reports, Lab test, Viva, Quiz

	with respect to theoretical knowledge				
CO4	Investigate the effect of parameter changes and performance of electrical machines	PO2	C6	Lectures, Experiment, Group discussion,	Lab reports, Lab test, Viva, Quiz

14.30.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓				✓			✓	✓						✓	✓			

14.30.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments and Laboratory machines; Formation of groups/teams for laboratory works	CO1
2	Experiment 01	The Single-Phase Transformer; To study the voltage and current ratios of a transformer; To learn about transformer exciting currents, volt-ampere capacity and short circuit currents	CO2
3	Experiment 02	Transformer Polarity; To determine the polarity of transformer windings; To learn how to connect transformer windings in series aiding; To learn how to connect transformer windings in series opposing.	CO2
4	Experiment 03	Transformer Regulation; To study the voltage regulation of the transformer with varying loads; To study transformer regulation with inductive and capacitive loading.	CO2
5	Experiment 04	Determination of the Equivalent Circuit Parameters of a Transformer and Calculation of Efficiency and Regulation using Equivalent Circuit	CO2
6	Experiment 05	Experiment on single phase induction motor; To measure the starting and operating characteristics of the Capacitor-Start motor.	CO3
7	Experiment 06	The Wound-Rotor Induction Motor; To observe the characteristics of the wound-rotor induction motor	CO3

		at no load and at full load; To observe speed control using an external variable resistance	
8	Experiment 07	The Three-Phase Alternator; To obtain the no load saturation curve of the alternator; To obtain the short-circuit characteristics of the alternator.	CO3
9	Experiment 08	Alternator Synchronization; To learn how to synchronize an alternator to the electric power utility system; To observe the effects of improper phase conditions on the synchronizing process.	CO4
10-11	Practice	Students will practice all of the above experiments.	-
12	Lab Quiz	A Quiz will be held based on all experiments.	-
13-14	Lab test/Viva	A comprehensive Lab exam will be taken.	-

14.30.7 Assessment Pattern/ Strategy

Assessment will be based on following indicators.

Class Attendance: Attendance of every lab session will be recorded.

Lab Report: After completing each laboratory experiment, each student has to write a laboratory report on that experiment. Students will have one week to submit the laboratory report. Oral test will be taken based on submitted report.

Quiz: After the completion of all laboratory experiment, a quiz test will be taken.

Lab Test & Viva: Each student has to perform a laboratory experiment during lab test. After the lab test, an oral exam will be taken based on the experiments.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.30.8 Text Books and Reference Books

1) Electric Machinery Fundamentals, 5th Edition, Stephen J. Chapman, McGraw-Hill Education.

2) Electric Machinery, 6th Edition, A.E. Fitzgerald, Charles Kingsley, JR and Stephen D. Uman, McGraw-Hills.

3) A Text Book of Electrical Technology, Volume II, AC & DC Machines, B.L. Thereja, A.K. Thereja, 23rd Edition.

14.31 Mechanical Engineering Laboratory

14.31.1 Introduction of the Course

Course Code and Title: 0715-MEC-2206: Mechanical Engineering Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: Mechanical Engineering Laboratory is to provide students with hands-on experimental experience that complements and reinforces the theoretical concepts learned in the related Fundamentals of Mechanical Engineering course (0715-MEC-2205). Through practical laboratory exercises and projects, students will gain skills in taking measurements, analyzing data, and conducting experiments related to key mechanical engineering principles. They will learn to use common laboratory equipment and instrumentation, apply engineering principles to real-world systems, and develop their technical writing and reporting skills. The course aims to enhance students' understanding of topics covered in the lecture course through practical application, while also improving their teamwork, critical thinking, and problem-solving abilities. This laboratory experience is essential for bridging theory and practice, preparing students for their future engineering careers by developing crucial hands-on skills and experimental methods.

Prerequisites (if any): No prerequisite.

14.31.2 Course Objectives

The students are expected to

1) Develop practical skills in conducting experiments related to fundamental mechanical engineering principles, with a focus on thermal systems and measurements.

2) Gain hands-on experience with laboratory equipment and instrumentation commonly used in mechanical engineering applications.

3) Apply theoretical concepts learned in the related Fundamentals of Mechanical Engineering course to real-world experimental setups and scenarios.

4) Enhance data analysis and technical writing skills through the preparation of comprehensive lab reports documenting experimental procedures, results, and conclusions.

5) Cultivate critical thinking and problem-solving abilities by troubleshooting experimental setups, analyzing unexpected results, and interpreting experimental data in the context of engineering principles.

14.31.3 Course Content

Experiments in relevance with the 0715-MEC-2205 Fundamentals of Mechanical Engineering course.

Projects related to 0715-MEC-2205 Fundamentals of Mechanical Engineering course contents to achieve specific program outcomes.

14.31.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools

CO1	Conduct experiments related to mechanical engineering principles and accurately measure physical quantities.	PO1	C3	Lectures, Hands-on Lab Experiment	Lab Reports, Viva, Practical Tests
CO2	Analyze experimental data and apply theoretical concepts to interpret results.	PO2	C4, A3	Lectures, Data Analysis, Group Discussions	Lab Reports, Assignment s
CO3	Use laboratory equipment and tools effectively to perform mechanical engineering experiments	PO3	P5, A2	Demonstrat ions, Practical Sessions	Practical Exams, Lab Reports
CO4	Work collaboratively in teams to solve engineering problems and complete lab projects.	PO9	C6, A4	Group Projects, Team-based Experiment	Project Reports, Presentatio ns
CO5	Communicate experimental findings clearly through technical reports and presentations.	PO10	C2, A2	Report Writing Workshops, Presentatio n	Reports, Presentatio ns

14.31.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓				✓								✓	✓	✓	

14.31.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs

1	Experiment 1	Characteristics study of different sensors.	CO1, CO2, CO3
2	Experiment 2	An experiment to measure the unknown length of a given aluminum rod by determining the thermal conductivity.	CO1, CO2, CO3
3	Experiment 3	To determine the mean emissivity of a copper/aluminum plate at different temperatures.	CO1, CO2, CO3
4	Experiment 4	To determine the linear expansion of iron/copper/aluminum/quartz glass/brass as a function of temperature using a dilatometer.	CO1, CO2, CO3
5	Experiment 5	To investigate the relationship between change in length and overall length in the case of aluminum	CO1, CO2, CO3
6	Experiment 6	To determine the healing capacity of the pump and its efficiency rating at constant current and constant temperature on the cold side.	CO1, CO2, CO3
7	Experiment 7	To determine heating capacity, efficiency rating at constant current, cooling capacity, and efficiency rating at the maximum output from the relationship between temperature and time on the hot and cold sides.	CO1, CO2, CO3
8	Experiment 8	Basic vapor compression refrigeration cycle experiment	CO1, CO2, CO3
9	Experiment 9	Heat pump performance experiment	CO1, CO2, CO3
10	Project proposal Presentation	Design projects related to thermal sensors, heat conductivity and refrigeration.	CO4
11	Project Work	Execute the design	CO4
12	Project demonstration	Demonstration group wise projects	CO4, CO5
13-14	Final Exams	Utilize multimedia and appropriate documentation to effectively communicate the project; demonstrate that specific technical requirements have been met by the project.	CO5

14.31.7 Assessment Pattern/ Strategy

Assessment will be based on laboratory performance on prompt understanding, knowledge base, and clear understanding of the theory and practical. Project proposal will be assessed with presentation and system design.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.31.8 Text Books and Reference Books

1) Concepts in Thermal Physics, 2nd Edition, Stephen J. Blundell and Katherine M. Blundell, Oxford University Press.

2) Thermal System Design: Fundamentals and Projects, 2nd Edition, Richard J. Martin, Wiley.

3) Handbook of Air Conditioning and Refrigeration, Shah K Wang, Mc Graw Hill.

14.32 Electromagnetic Theory and Antenna

14.32.1 Introduction of the Course

Course Code and Title: 0714-EEE-3101: Electromagnetic Theory and Antenna.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the principles and applications of electromagnetics in modern communication systems. This course lays the groundwork for understanding how electromagnetic fields are generated, transmitted, and received, which is essential for the design and analysis of various electronic and communication devices. By exploring Maxwell's equations, wave propagation, transmission lines, waveguides, and diverse antenna structures, students gain the knowledge necessary to innovate and improve technologies in telecommunications, radar, broadcasting, and other fields reliant on electromagnetic wave propagation.

Prerequisites (if any): 0533-PHY-1103: Electricity and Magnetism, 0541-MAT-1209: Vector Calculus and Complex Analysis, 0541-MAT-2111: Ordinary and Partial Differential Equations.

14.32.2 Course Objectives

The students are expected to

1) Gain a thorough understanding of Maxwell's equations in both differential and integral forms to solve problems related to electromagnetic fields and waves, including the analysis of wave behavior in various mediums.

2) Develop the ability to model and analyze transmission lines, and acquire a deep understanding of wave propagation principles in different types of waveguides.

3) Investigate the principles of antenna radiation mechanisms, design various antenna types, and carry out practical measurements to assess antenna performance for specific applications.

14.32.3 Course Content

Electromagnetics: Maxwell’s Equation: Differential and Integral Forms, Constitutive Relations, Complex Dielectric Constant, Linear and Nonlinear Mediums, Boundary Conditions for Different Interfaces, Poynting Theorem, Potential Functions, Vector Wave Equation, Wave Equation in 3D, Uniform Plane Wave (UPW) in Lossless Medium, UPW in Lossy Medium, Skin Depth, DC and AC Resistance, Loss Tangent.

Transmission Line (TL): TL Equivalent Circuit of a Small Section, TL Equations or Telegraph’s Equations, Characteristic Impedance, Quarter-Wave Transformer, Reflection Coefficient, VSWR, Determining Unknown Load-Impedance, Impedance Matching and Tuning using Smith Chart, Microstrip Lines.

Waveguides: Rectangular and Cylindrical, TE and TM Modes, Dominant/ Fundamental Mode, Single-Multimode, Cut-off Frequency/Wavelength, Power Flow, Resonant Cavities and Dielectric Slab Waveguide.

Antenna: Radiation Mechanism of Antenna, Types of Antennas, Radiation Patterns, Major and Minor Lobes, Equivalent Circuit of a Transmitting Antenna, Generated and Radiated Power Ratio, Near and Far Field Approximations, Antenna Efficiency, Effective Aperture, Antenna Beamwidth and Bandwidth, Wire Antennas such as Hertzian, Half-Wave Dipole and Monopole, Expressions for Surface Power Density or Poynting Vector, Radiation Intensity, Directivity, Gain, Radiation Resistance and Radiation Pattern for Far Fields, Antenna Arrays: Array Factor, Main Lobe Direction, Nulls, Secondary Maxima, HPBW, Broadside Array, End-Fire Array, Horns, Reflector Type Antennas, Frequency Independent Antennas, Microstrip Patch Antennas, Antenna Measurements.

14.32.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Apply Maxwell's equations in both differential and integral forms to analyze and solve complex problems related to electromagnetic fields and wave propagation in various mediums	PO1, PO2, PO3	C3, C4	Lectures Discussions	Assignment Presentation

CO2	Analyze and design transmission lines and explore the principles of wave propagation in waveguides	PO1, PO2, PO3, PO4	C3, C4, C5	Exercise Handouts	Incourse Final Exam
CO3	Investigate and design different types of antennas, as well as measure and evaluate antenna parameters for practical applications	PO1, PO3, PO5, PO9	C3, C4, C5, C6, P3, P4, P5	Exercise Handouts	Incourse Final Exam

14.32.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓	✓			✓	✓	✓	✓	✓					✓	✓		✓

14.32.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Week	Lecture	Topics	COs
1	1-2	TL equivalent circuit of a small section, TL equations (Telegraph's equations), Characteristic impedance	CO2
2	3-4	Reflection coefficient, VSWR, Determining unknown load-impedance, Impedance matching using Smith Chart, Quarter-wave transformer	CO2
3	5-6	Maxwell's Equations (Differential and Integral Forms), Constitutive relations, Complex dielectric constant, Linear and nonlinear mediums	CO1
4	7-8	Boundary conditions for different interfaces, Poynting theorem, Potential functions, Vector wave equation	CO1
5	9-10	Wave equation in 3D, Uniform plane wave in lossless medium, UPW in lossy medium, Skin depth, DC and AC resistance, Loss tangent	CO1
6	11-12	Tuning techniques, Microstrip Lines: Design principles, Applications, Practical considerations	CO2
7	13-14	Rectangular Waveguides, TE and TM modes, Dominant/ fundamental mode, Single-multimode operation	CO2

8	15-16	Cylindrical Waveguides, Mode analysis, Cut-off frequency/ wavelength, Power flow, Resonant cavities, Dielectric slab waveguide	CO2
9	17-18	Radiation mechanism, Types of antennas, Radiation patterns, Major and minor lobes, Equivalent circuit of transmitting antenna	CO3
10	19-20	Generated and radiated power ratio, Near and far field approximations, Antenna efficiency, Effective aperture, Antenna beamwidth and bandwidth	CO3
11	21-22	Wire Antennas: Hertzian dipole, Half-wave dipole, Monopole, Surface power density calculations, Radiation intensity	CO3
12	23-24	Directivity, Gain, Radiation resistance, Far field radiation patterns, Array factor, Main lobe direction	CO3
13	25-26	Nulls and secondary maxima, HPBW, Broadside array, End-fire array, Horn antennas, Reflector type antennas	CO3
14	27-28	Frequency independent antennas, Microstrip patch antennas, Antenna measurements, Review of critical concepts	CO3

14.32.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.32.8 Text Books and Reference Books

1) Microwave Engineering, 4th Edition, David M. Pozar, John Wiley & Sons, Inc.

2) Elements of Electromagnetics, 4th Edition, Matthew N.O. Sadiku, Oxford University Press.

3) Fundamentals of Applied Electromagnetics, 6th Edition, F.T. Ulaby, Prentice Hall, Boston.

4) Microwave Devices and Circuits, 3rd Edition, Y. Liao, Prentice Hall.

5) Antenna Theory: Analysis and Design, 4th Edition, Constantine A. Balanis, Wiley.

6) Antennas and Wave Propagation, G.S.N. Raju, Pearson.

7) Electronic Communications, 4th Edition, Dennis Roddy and John Coolen, Pearson.

8) Radio Frequency and Microwave Electronics Illustrated, 1st Edition, Matthew M. Radmanesh, Prentice Hall.

9) Foundations for Microwave Engineering, 2nd Edition, Robert E Collin, Wiley.

10) Engineering Electromagnetics, 8th Edition, William Hayt and John Buck, McGraw-Hill Education.

11) Advanced Engineering Electromagnetics, 2nd Edition, Constantine A. Balanis, Wiley.

14.33 Microprocessor and Interfacing

14.33.1 Introduction of the Course

Course Code and Title: 0714-EEE-3103: Microprocessor and Interfacing.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is a comprehensive course designed to equip students with essential knowledge in microprocessor systems and interfacing techniques, providing them insights into the world of microprocessors and their applications. Throughout this course, students will delve into the intricacies of the 8086 microprocessor, interrupts, assembly language programming, memory types, I/O interfacing, and DMA (Direct Memory Access).

Prerequisites (if any): 0714-EEE-2103: Digital Electronics.

14.33.2 Course Objectives

The students are expected to

1) Develop a foundational understanding of microcomputer systems, including the classification and evolution of microprocessors, and distinguish between microprocessors and microcontrollers.

2) Analyze the architecture of the 8086 microprocessor, including its basic components, registers, flags, and operation in real mode. Understand memory segmentation and the physical addressing scheme.

3) Investigate the concept of interrupts, including the interrupt vector table, hardware and software interrupts, and the role of the Programmable Interrupt Controller (8259A). Implement interrupt-driven I/O.

4) Acquire skills in assembly language programming (ALP), including the use of macros and procedures. Utilize program development tools and processes to write ALPs that involve various I/O functions.

5) Understand different types of memory, memory banks, and the memory read-write cycle. Explore I/O instructions, basic I/O interfacing, and the decoding of I/O port addresses. Study interfacing components such as the Programmable Peripheral Interface (8255A IC) and Programmable Interval Timer (8254).

6) Learn the basics of Direct Memory Access (DMA) operations, including the role of the DMA controller and DMA processed interface.

14.33.3 Course Content

Introduction to Microprocessor: Microcomputer System, Classification and Evolution of Microprocessor, Difference between Microprocessor and Microcontroller.

8086 Microprocessor: Basic Architecture, Registers, Flags, Real Mode Operation of 8086 Microprocessor, Segment, Offset and Physical Address, Instruction Format, Functions of Different Instructions of 8086 Microprocessor, Pins and Signals, Bus Buffering and Latching, Bus Timing, Ready and Wait State Generation, Clock Generator (8284A), Memory Segmentation.

Interrupts: Introduction to Interrupts, Interrupt Vector Table, Interrupt Instructions and Operation, Hardware and Software Interrupts, Interrupt Driven I/O, Programmable Interrupt Controller (8259A).

Microprocessor Programming: Introduction to Assembly Language Programming (ALP), Macro and Procedure, Program Development Tools, Program Development Process, Writing Simple ALPs using Different I/O Functions, Macros, Procedures.

Memory: Memory Types, Memory Banks, Memory Read-Write Cycle, Memory Interfacing.

I/O Interfacing: I/O Instructions, Basic I/O Interfacing, I/O Port Address Decoding, Programmable Peripheral Interface (8255A IC), Peripheral Interfacing Examples, Programmable Interval Timer (8254), Timer Interfacing, D/A and A/D Converter, Programmable Communication Interface, Interfacing Serial I/O Devices.

DMA: Basic DMA Operation, DMA Controller, DMA Processed Interface.

14.33.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the architecture, registers, flags, and real mode operation of the 8086 microprocessor	PO1	C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Demonstrate proficiency in assembly language programming for microprocessors	PO2	C3	Lectures Discussions Exercise	Assignment Final Exam
CO3	Develop insight into interfacing microprocessors	PO3	C3, C5	Lectures Discussions Exercise	Assignment Final Exam

	with various peripherals				
CO4	Investigate the concept of interrupts, understand interrupt-driven I/O techniques and address interrupt-related challenges	PO3	C4, C6	Lectures Discussions	Incourse Final Exam Presentatio n

14.33.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
		✓	✓		✓			✓	✓					✓	✓	✓	✓		✓

14.33.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Microcomputer system, classification and evolution of microprocessor, difference between microprocessor and microcontroller, basic architecture of microprocessor	CO1
2	3-4	Registers, flags, pins and signals, real mode operation, segment, offset, and physical address of 8086 microprocessor	CO1
3	5-6	Instruction format, memory segmentation, addressing and memory organization of 8086 microprocessor	CO1
4	7-8	Addressing modes of 8086 microprocessor	CO1
5-6	9-12	Instruction set of 8086 microprocessor	CO2
7	13-14	Introduction to assembly language programming, macros and procedures, ALP development tools and process	CO2
8	15-16	Memory devices, different types of ROM, RAM etc. address decoding, memory interfacing	CO1 CO3
9	17-18	I/O instructions, I/O interfacing, I/O address decoding	CO2 CO3
10-11	19-20	8255 PPI, 8254 Timer, 16550 PCI, D/A, A/D converters	CO3
12-13	23-26	Interrupts, interrupt instructions, real mode and protected mode interrupts, Hardware interrupt, 8255 keyboard interrupt, 8259 interrupt controller	CO3 CO4
14	27-28	Real time clock, DMA operation, 8237 DMA controller, DMA processed printer interface	CO3 CO4

14.33.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.33.8 Text Books and Reference Books

1) Intel Microprocessor: Architecture, Programming and Interfacing, Barry B. Brey, 8th Edition, Pearson Prentice Hall.

2) Microprocessors and Interfacing: Programming and Hardware, Douglas V. Hall, 2nd Edition, Macmillan/McGraw-Hill.

3) Microcomputer Systems 8086/8088 Family: Architecture, Programming and Design, Yu-Cheng Liu and Glenn A. Gibson, 1st Edition, Prentice Hall.

4) Microprocessor and Interfacing: 8086, 8051, 8096 and Advanced Processors, N.S. Kumar, M. Saravanan, S. Jeevananthan and S.K. Shah, Oxford University Press.

5) Understanding 8085/8086 Microprocessors and Peripheral ICs through Questions and Answers, S.K. Sen, 2nd Edition, New Age International Publishers.

6) Microprocessor X86 Programming, K.R. Venugopal and Raj Kumar, BPB Publications.

7) Assembly Language Programming and Organization of the IBM PC, Y. Yu and C. Marut, International Edition, Mitchell McGraw-Hill.

14.34 Communication Systems

14.34.1 Introduction of the Course

Course Code and Title: 0714-EEE-3105: Communication Systems.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: In today's rapidly evolving technological landscape, effective communication systems serve as the backbone of global connectivity and information exchange. This course offers students a comprehensive understanding of both the theoretical and practical aspects of modern communication systems, providing a solid foundation in the field. It prepares students to tackle challenges and capitalize on opportunities in the ever-evolving realm of communication technology. By bridging the gap between theoretical concepts and practical implementation, the course ensures graduates are equipped to make significant contributions to the industry.

Prerequisites (if any): 0714-EEE-2101: Analog Electronics I, 0714-EEE-2109: Signals and Systems, 0714-EEE-2201: Analog Electronics II.

14.34.2 Course Objectives

This course covers a broad spectrum of topics, starting with the fundamental principles and elements of communication systems. It delves into the nuances of noise, its sources, and its impact on signal integrity. By exploring both analog and digital communication methods, students gain a well-rounded perspective on various modulation and demodulation techniques. The inclusion of multiplexing and multiple-access methods further enhances their understanding of how to efficiently manage bandwidth and resources in complex communication networks.

The students are expected to

1) Gain a comprehensive understanding of the fundamental elements, limitations, and requirements of communication systems, including message source, bandwidth, and transmission media.

2) Identify the various sources and characteristics of noise, understand signal-to-noise ratio, and apply noise mitigation techniques to improve system performance.

3) Study the principles, bandwidth requirements, transmission types, modulation and demodulation techniques, spectral analysis, receiver design, and noise performance of analog and digital communication systems.

4) Investigate various multiplexing methods (TDM, FDM, WDM) and multiple-access techniques (TDMA, FDMA, CDMA), including their principles, synchronization, and performance constraints.

5) Develop the ability to design communication systems by selecting appropriate channels, simulation of performance, and considering relevant design parameters and criteria.

14.34.3 Course Content

Overview of Communication Systems: Basic Principles, Fundamental Elements, System Limitations, Message Source, Bandwidth Requirements, Transmission Media Types, Bandwidth and Transmission Capacity.

Noise: Sources of Noise, Characteristics of Various Types of Noise and Signal to Noise Ratio.

Analog Communication Systems: Continuous Wave Modulation: Transmission Types, Base-Band Transmission, Carrier Transmission, Amplitude Modulation- Introduction, Double Side Band, Single Side Band, Vestigial Side Band, Quadrature, Spectral Analysis of Each Type, Envelope and Synchronous Detection, Angle Modulation-Instantaneous Frequency, Frequency Modulation (FM) and Phase Modulation (PM), Spectral Analysis, Demodulation of FM and PM, AM Broadcast Technical Standards, AM Transmitter and Receiver, Superheterodyne Receiver, FM Transmitters and Receivers, Comparison of AM and FM Receivers, Noise in Receiver, Noise Limiting Circuits, AGC Circuits, Receiver Sensitivity, Cross Modulation, Spurious Response Converters, Detector and Modulation

Circuits, Sampling- Sampling Theorem, Nyquist Criterion, Aliasing, Instantaneous and Natural Sampling, Flat-Topped Sampling, Pulse Amplitude Modulation- Principle, Bandwidth Requirements, Pulse Code Modulation (PCM)- Quantization Principle, Quantization Noise, Nonuniform Quantization, Signal to Quantization Noise Ratio, Differential PCM, Demodulation of PCM, Delta Modulation (DM)- Principle, Adaptive DM, Delta-Sigma Modulation, Adaptive DPCM (ADPCM), Line Coding- Formats and Bandwidths.

Digital Modulation and Demodulation: Amplitude-Shift Keying-Principle, ON- OFF Keying, Bandwidth Requirements, Detection, Noise Performance, Phase-Shift Keying (PSK)- Principle, Bandwidth Requirements, Detection, Differential PSK, Quadrature PSK, Noise Performance, Frequency-Shift Keying (FSK)- Principle, Continuous and Discontinuous Phase FSK, Minimum-Shift Keying (MSK), GMSK, Bandwidth Requirements, Detection of FSK, Multilevel Signaling, M-Ary Modulation Techniques, Spread Spectrum Modulation Techniques, DSSS, FHSS.

Multiplexing: Time-Division Multiplexing (TDM), Principle, Receiver Synchronization, Frame Synchronization, TDM of Multiple Bit Rate Systems, Frequency-Division Multiplexing (FDM) Principle, Demultiplexing; Wavelength- Division Multiplexing, Multiple-Access Network- Time-Division Multiple-Access (TDMA), Frequency-Division Multiple Access (FDMA), Code-Division Multiple- Access (CDMA) Spread Spectrum Multiplexing, Coding Techniques and Constraints of CDMA.

Communication System Design: Design Parameters, Channel Selection Criteria and Performance Simulation.

14.34.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the basic principles of communication systems	PO1	C1, C2, P1	Lectures, Discussions, Handout	Assignment In-course Final Exam
CO2	Analyze and mitigate noise in communication systems	PO1, PO2	C1, C2, P1	Lectures, Discussions, Handout	Assignment In-course Final Exam
CO3	Examine and differentiate analog and digital communication techniques	PO1	C4, P1	Lectures, Discussions, Handout	Assignment In-course Final Exam
CO4	Understand multiplexing and multiple access techniques	PO1	C1, C2, P1	Lectures, Discussions, Handout	Assignment In-course Final Exam

CO5	Design and evaluate communication systems	PO3	C1, C2, C3, C6, P1, P3	Lectures, Discussions, Handout	Assignment In-course Final Exam

14.34.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓					✓	✓						✓	✓			

14.34.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Overview of Communication Systems: Basic Principles, Fundamental Elements, System Limitations, Message Source, Bandwidth Requirements, Transmission Media Types, Bandwidth and Transmission Capacity. Noise: Sources of Noise, Characteristics of Various Types of Noise and Signal to Noise Ratio.	CO1, CO2
2	3-4	Analog Communication Systems: Continuous Wave Modulation: Transmission Types, Base-Band Transmission, Carrier Transmission, Amplitude Modulation- Introduction, Double Side Band, Single Side Band, Vestigial Side Band, Quadrature Amplitude Modulation.	CO1
3	5-6	Spectral Analysis of Each Type, Envelope and Synchronous Detection, AM Broadcast Technical Standards, AM Transmitter and Receiver, Superheterodyne Receiver.	CO1
4	7-8	Angle Modulation-Instantaneous Frequency, Frequency Modulation (FM) and Phase Modulation (PM), Spectral Analysis, Demodulation of FM and PM, FM Transmitters and Receivers, Comparison of AM and FM Receivers, Noise in Receiver, Noise Limiting Circuits, AGC Circuits, Receiver Sensitivity, Cross Modulation, Spurious Response Converters, Detector and Modulation Circuits.	CO1
5-6	9-12	Sampling- Sampling Theorem, Nyquist Criterion, Aliasing, Instantaneous and Natural Sampling, Flat-Topped Sampling, Pulse Amplitude Modulation- Principle, Bandwidth Requirements, Pulse Code Modulation (PCM)- Quantization Principle, Quantization Noise, Nonuniform Quantization, Signal to Quantization Noise Ratio, Differential PCM, Demodulation of PCM	CO1, CO3

7	13-14	Delta Modulation (DM)- Principle, Adaptive DM, Delta-Sigma Modulation, Adaptive DPCM (ADPCM), Line Coding-Formats and Bandwidths.	CO1
8	15-16	Digital Modulation and Demodulation: Amplitude-Shift Keying-Principle, ON- OFF Keying, Bandwidth Requirements, Detection, Noise Performance, Phase-Shift Keying (PSK)- Principle, Bandwidth Requirements, Detection.	CO1, CO3
9	17-18	Differential PSK, Quadrature PSK, Noise Performance, Frequency-Shift Keying (FSK)- Principle, Continuous and Discontinuous Phase FSK, Minimum-Shift Keying (MSK), GMSK, Bandwidth Requirements, Detection of FSK, Multilevel Signaling, M-Ary Modulation Techniques	CO1, CO3
10-11	19-20	Spread Spectrum Modulation Techniques, DSSS, FHSS.	CO1
12-13	23-26	Multiplexing: Time-Division Multiplexing (TDM), Principle, Receiver Synchronization, Frame Synchronization, TDM of Multiple Bit Rate Systems, Frequency-Division Multiplexing (FDM) Principle, Demultiplexing; Wavelength- Division Multiplexing, Multiple-Access Network- Time-Division Multiple-Access (TDMA), Frequency-Division Multiple Access (FDMA), Code-Division Multiple- Access (CDMA) Spread Spectrum Multiplexing, Coding Techniques and Constraints of CDMA.	CO4
14	27-28	Communication System Design: Design Parameters, Channel Selection Criteria and Performance Simulation.	CO5

14.34.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.34.8 Text Books and Reference Books

1) Introduction to Spread Spectrum Communications, R.L. Peterson, R.E. Ziemer and D.E. Borth, Prentice Hall.

2) Differential Geometry in Array Processing, A. Manikas, Imperial College Press.

3) Digital Communications, I. A. Glover & P.M. Grant, Prentice Hall.

4) Digital Communications Fundamentals and Applications, Sklar B, Prentice Hall.

5) Introduction to Digital Communications, R.E. Ziemer & R.L. Peterson, MacMillan.

6) Communication Systems, 4th Edition, Simon Haykin, Wiley.

7) Digital Communications Systems, 1st Edition, Simon Haykin, Wiley.

8) Communication Systems Engineering, 2nd Edition, John G. Proakis and Masoud Salehi, Pearson.

9) Probability, Random Variables and Stochastic Processes, 4th Edition, Athanasios Papoulis and S. Unnikrishna Pillai, McGraw-Hill Europe.

10) Principles of Communications: Systems, Modulation, and Noise, 4th Edition, Rodger E. Ziemer and W. H. Tranter, Wiley.

11) Modern Digital and Analog Communication Systems, 4th Edition, B.P. Lathi, Zhi Ding and Hari Mohan Gupta, Oxford University Press.

12) Principles of Communication Systems, 4th Edition, Herbert Taub, Donald Schilling and Goutam Saha, McGraw-Hill Education.

14.35 Industrial and Medical Instrumentation

14.35.1 Introduction of the Course

Course Code and Title: 0714-EEE-3107: Industrial and Medical Instrumentation.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Industrial and medical instrumentation play a crucial role in modern engineering applications, enabling precise measurement, control, and monitoring of various physical and biological parameters. This course provides a comprehensive understanding of electronic, mechanical, and biomedical instrumentation, covering fundamental principles, sensor technologies, signal acquisition, and advanced imaging and therapeutic devices. By studying this course, students will develop the ability to analyze, design, and troubleshoot instrumentation systems used in industrial automation and healthcare.

Prerequisites (if any): No prerequisite.

14.35.2 Course Objectives

The students are expected to

1) Understand the working principles and applications of various electronic, displacement, force, temperature, and pressure instrumentation systems.

2) Analyze and evaluate process instrumentation techniques in industrial applications.

3) Gain insights into biopotential instrumentation and modern imaging systems used in medical diagnostics and therapeutic procedures.

4) Explore advanced medical instruments such as radiotherapy systems, oximeters, spectrophotometers, and diathermy devices.

5) Develop problem-solving skills to design, select, and implement appropriate instrumentation solutions for industrial and medical applications.

14.35.3 Course Content

Electronic Instrumentation: Sine-Wave Generator, Arbitrary Function Generator, Pulse Train Generator, Sweep Frequency Generator, Spectrum Analyzer, Frequency Analyzer, Digital Voltmeter: Stair-Case, Successive Approximation Type, Integrating, Dual Slope Integrating Type, Delta Pulse Modulation Type,

Cathode Ray Oscilloscope: Construction, Time Base, Waveform Display, Trigger, Probe and Control.

Displacement Instrumentation: Potentiometer, Differential Transformer, Capacitance Transducers, Rotational Speed Measurement using Tacho Generator.

Force Instrumentation: Strain Gauge, Piezo-Electric Transducers, Force Transducers, Acceleration Transducers, Torque Transducers.

Temperature Instrumentation: Resistance Thermometer Detectors (RID), Thermistors, Thermocouple, Photovoltaic Sensor, Infra-Red Thermometry,

Radiation Detection.

Pressure Instrumentation: Strain Gauge Based, Capacitance Based, Thermocouple Gauge, Flow Meter: Differential Pressure Measurement, VenturiMeter, Magnetic Flowmeter, Ultrasonic Flowmeter, Capacitive Based Level

Sensor and Ultrasonic Level Sensor.

Process Instrumentation: Humidity Sensor, Density and Specific Gravity Sensor, Viscosity Sensor, Regulators and Safety Valves and Flow Control Actuators.

Biopotential Instrumentation: The Origin of Biopotentials, ECG, EEG, EMG, Biopotential Electrodes, Arrhythmia Monitor, QRS Detection Techniques, Cardiac Defibrillators, Cardiac Pacemaker.

Modern Imaging Systems: X-ray Machines, X-ray Computed Tomography, Nuclear Medical Imaging Systems, The Gamma Camera, Emission Computed Tomography, Single-Photon Emission Computed Tomography, Positron Emission Tomography, Magnetic Resonance Imaging System, Ultrasonic Imaging Systems and Thermal Imaging System.

Radiotherapy Instrumentation: High Voltage X-ray Machines, Betatron, Cobalt-60 Machine, Medical Linear Accelerator Machine.

Miscellaneous: Oximeter, Blood Flow Meter, Spectrophotometer, Blood Cell Counter, High Frequency Heat Therapy, Short-wave Diathermy, Microwave Diathermy and Ultrasonic.

14.35.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools

CO1	Understand the principle of operation and design details of electronic instruments, transducers, sensor used in laboratory, industry and biomedical engineering	PO1, PO2	C1	Lectures Discussions	Incourse Final Exam
CO2	Analyze and process signals obtained from different types of transducers and sensors and biomedical signals	PO2, PO5	C4, C5	Lectures Discussions	Assignment Presentation Final Exam
CO3	Acquire knowledge on industrial instrumentation, medical imaging, working principle and design of imaging machines	PO3, PO4	C2, C3	Lectures Discussions Exercise	Assignment Final Exam
CO4	Understand the measurement process of body signal interpretation, diagnosis and therapy	PO1	C1, C4	Lectures Discussions	Presentation Final Exam
CO5	Design, development and modification of different types of medical devices	PO4	C3	Lectures Discussions Exercise	Incourse Final Exam

14.35.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓

14.35.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Electronic Instrumentation: Sine-Wave Generator, Arbitrary Function Generator, Pulse Train Generator, Sweep Frequency Generator, Spectrum Analyzer, Frequency Analyzer,	CO1
2	3-4	Digital Voltmeter: Stair-Case, Successive Approximation Type, Integrating, Dual Slope Integrating Type, Delta Pulse Modulation Type, Cathode Ray Oscilloscope: Construction, Time Base, Waveform Display, Trigger, Probe and Control.	CO1
3	5-6	Displacement Instrumentation: Potentiometer, Differential Transformer, Capacitance Transducers, Rotational Speed Measurement using Tacho Generator.	CO2
4	7-8	Force Instrumentation: Strain Gauge, Piezo-Electric Transducers, Force Transducers, Acceleration Transducers, Torque Transducers.	CO2, CO3
5	9-10	Temperature Instrumentation: Resistance Thermometer Detectors (RID), Thermistors, Thermocouple, Photovoltaic Sensor,	CO2, CO3
6	11-12	Infra-Red Thermometry, Radiation Detection.	CO3
7	13-14	Pressure Instrumentation: Strain Gauge Based, Capacitance Based, Thermocouple Gauge, Flow Meter: Differential Pressure Measurement, VenturiMeter, Magnetic Flowmeter,	CO3
8	15-16	Ultrasonic Flowmeter, Capacitive Based Level, Sensor and Ultrasonic Level Sensor.	CO2, CO3
9	17-18	Process Instrumentation: Humidity Sensor, Density and Specific Gravity Sensor, Viscosity Sensor, Regulators and Safety Valves and Flow Control Actuators.	CO3
10	19-20	Biopotential Instrumentation: The Origin of Biopotentials, ECG, EEG, EMG, Biopotential Electrodes, Arrhythmia Monitor, QRS Detection Techniques, Cardiac Defibrillators, Cardiac Pacemaker.	CO4
11	21-22	Modern Imaging Systems: X-ray Machines, X-ray Computed Tomography, Nuclear Medical Imaging Systems, The Gamma Camera, Emission Computed Tomography, Single-Photon Emission Computed Tomography,	CO4
12	23-24	Positron Emission Tomography, Magnetic Resonance Imaging System, Ultrasonic Imaging Systems and Thermal Imaging System.	CO4, CO5
13	25-26	Radiotherapy Instrumentation: High Voltage X-ray Machines, Betatron, Cobalt-60 Machine, Medical Linear Accelerator Machine.	CO5
14	27-28	Miscellaneous: Oximeter, Blood Flow Meter, Spectrophotometer, Blood Cell Counter, High Frequency Heat Therapy, Short-wave Diathermy, Microwave Diathermy and Ultrasonic.	CO5

14.35.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.35.8 Text Books and Reference Books

1. Electronic Instrumentation and Measurement Techniques – William David Cooper
2. Electronic Instrumentation and Measurements, 2nd Edition, David A. Bell, Prentice Hall.
3. Modern Electronic Instrumentation and Measurement Techniques, Albert D Helfrick and William D. Cooper.
4. Industrial Instrumentation, Tattamangalam R. Padmanabhan, Springer.
5. Fundamentals of Industrial Instrumentation and Process Control, 2nd Edition, William C. Dunn, McGraw-Hill.
6. Handbook of Biomedical Instrumentation, 2nd Edition, R S Khandpur, Tata McGraw-Hill.
7. Medical Instrumentations, 4th Edition, John G. Webster, John-Wiley and Sons.

14.36 Electronic Devices

14.36.1 Introduction of the Course

Course Code and Title: 0714-EEE-3109: Electronic Devices.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the underlying physics behind the working of semiconductor devices which form the backbone of the current integrated circuit (IC) technology. The course not only focuses on the theoretical foundations of semiconductor device physics but also delves into practical applications, enabling students to navigate the intricacies of electronic components such as bipolar junction transistors (BJTs), metal-oxide-semiconductor (MOS) capacitors and MOS field-effect transistors

(MOSFETs). By incorporating emerging device architectures and their underlying physics, the course anticipates preparing students for the dynamic landscape of electronic device engineering.

Prerequisites (if any): 0714-EEE-2105: Solid State Physics.

14.36.2 Course Objectives

The students are expected to

1) Develop a robust understanding of semiconductor fundamentals, energy bands, and carrier transport mechanisms.

2) Attain proficiency in analyzing and interpreting the characteristics of semiconductor devices, including PN junctions, metal-semiconductor junctions, BJTs, and MOSFETs.

3) Apply theoretical knowledge practically to design electronic devices to attain specified performance metrics.

4) Master emerging device architectures, such as multi-gate FETs, FinFETs, and high-k dielectric FETs.

14.36.3 Course Content

Semiconductor Fundamentals: Overview of Semiconductor Applications and Silicon IC Technology, Geometry of Crystals, Review of Quantum Mechanics, Energy Bands, Intrinsic and Extrinsic Semiconductors, Fermi Levels, Electron and Hole Concentrations, Temperature Dependence of Carrier Concentrations and Invariance of Fermi Level, Density of States, Fermi-Dirac Statistics.

Carrier Transport: Drift and Diffusion, Generation and Recombination of Excess Carriers, Built-in-Field, Recombination-Generation SRH Formula, Surface Recombination, Einstein Relations, Continuity and Diffusion Equations for Holes and Electrons and Quasi-Fermi Level.

PN Junction: Basic Structure and Operation, Energy Band Diagram under Equilibrium and Non-Equilibrium Conditions, Contact Potential, Equilibrium Fermi Level, Space Charge Region, Non-Equilibrium Condition, Forward and Reverse Bias, Carrier Injection, Minority and Majority Carrier Currents, PN Junction Electrostatics, Transient and AC Conditions, Time Variation of Stored Charge, Reverse Recovery Transient and Capacitance.

Metal-Semiconductor Junction: Ohmic Contact and Schottky Contacts, MS Junction Energy Band Diagram, PN Diode vs Schottky Diode I-V Characteristics, MS Junction Electrostatics.

Bipolar Junction Transistor: Basic Principle of PNP and NPN Transistors, Emitter Efficiency, Base Transport Factor and Current Gain, Diffusion Equation in the Base, Terminal Currents, Coupled-Diode Model and Charge Control Analysis, Ebers-Moll Model and Circuit Synthesis, BJT Non-Ideal Effects.

MOSFET: MOS Structure: MOS Capacitor, Energy Band Diagrams and Flat Band Voltage, MOS Capacitor under Applied Bias, Accumulation, Depletion, and Inversion Regions, Threshold Voltage and Control of Threshold Voltage, MOS Electrostatics, Static CV Characteristics, Qualitative Theory of MOSFET Operation, Body Effect and Current-Voltage Relationship of a MOSFET, Output and Transfer Characteristics, Non-Ideal Characteristics of MOSFET: Channel- Length Modulation and Short-Channel Effects in

MOSFET, DIBL, GIDL, MOS Scaling, High K-Metal Gate and Strained MOSFETs.

Emerging Devices: Introduction to Multi-gate FET Architecture, Structure and Basic Operation of Double Gate MOSFET, FinFET, Surrounding Gate FET, High- K Dielectric FETs.

14.36.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a comprehensive understanding of semiconductor fundamentals, including crystal geometry, energy bands, and carrier transport mechanisms	PO1	C2	Lectures Discussions Exercise Handouts	Assignment, Final Exam
CO2	Interpret and analyze the characteristics of semiconductor devices to draw conclusions about device performance	PO2, PO3	C4	Lectures Discussions Exercise Handouts	Incourse Final Exam
CO3	Apply theoretical knowledge practically to design electronic devices to attain specified performance metrics	PO3, PO5	C3, A2, P5	Lectures Discussions Exercise Handouts	Final Exam
CO4	Master emerging device architectures, such as multi-gate FETs,	PO4	C2	Class Demonstrations	Assignments

	FinFETs, and high-k dielectric FETs				

14.36.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓			✓	✓	✓		✓	✓	✓	✓				✓		✓	✓		✓

14.36.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Semiconductor Fundamentals: Overview of Semiconductor Applications and Silicon IC Technology, Geometry of Crystals	CO1
2	3-4	Semiconductor Fundamentals: Review of Quantum Mechanics, Energy Bands, Intrinsic and Extrinsic Semiconductors, Fermi Levels, Electron and Hole Concentrations, Temperature Dependence of Carrier Concentrations and Invariance of Fermi Level,	CO1
3	5-6	Semiconductor Fundamentals: Density of States, Fermi-Dirac Statistics.	CO1
4	7-8	Carrier Transport: Drift and Diffusion, Generation and Recombination of Excess Carriers, Built-in-Field, Recombination-Generation SRH Formula, Surface Recombination, Einstein Relations, Continuity and Diffusion Equations for Holes and Electrons and Quasi-Fermi Level.	CO1
5	9-10	PN Junction: Basic Structure and Operation, Energy Band Diagram under Equilibrium and Non-Equilibrium Conditions, Contact Potential, Equilibrium Fermi Level, Space Charge Region, Non-Equilibrium Condition	CO1, CO2
6	11-12	PN Junction: Forward and Reverse Bias, Carrier Injection, Minority and Majority Carrier Currents, PN Junction Electrostatics, Transient and AC Conditions, Time Variation of Stored Charge, Reverse Recovery Transient and Capacitance.	CO1, CO2
7	13-14	Metal-Semiconductor Junction: Ohmic Contact and Schottky Contacts, MS Junction Energy Band Diagram, PN Diode vs Schottky Diode I-V Characteristics, MS Junction Electrostatics.	CO1, CO2
8	15-16	Bipolar Junction Transistor: Basic Principle of PNP and NPN Transistors, Emitter Efficiency, Base Transport Factor	CO2, CO3

		and Current Gain,	
9	17-18	Bipolar Junction Transistor: Diffusion Equation in the Base, Terminal Currents, Coupled-Diode Model and Charge Control Analysis, Ebers-Moll Model and Circuit Synthesis, BJT Non-Ideal Effects.	CO2, CO3
10	19-20	MOSFET: MOS Structure: MOS Capacitor, Energy Band Diagrams and Flat Band Voltage, MOS Capacitor under Applied Bias, Accumulation, Depletion, and Inversion Regions, Threshold Voltage and Control of Threshold Voltage, MOS Electrostatics, Static CV Characteristics,	CO2, CO3
11	21-22	MOSFET: Qualitative Theory of MOSFET Operation, Body Effect and Current-Voltage Relationship of a MOSFET, Output and Transfer Characteristics, Non-Ideal	CO2, CO3
12	23-24	MOSFET: Characteristics of MOSFET: Channel- Length Modulation and Short-Channel Effects in MOSFET, DIBL, GIDL, MOS Scaling, High K-Metal Gate and Strained MOSFETs.	CO2, CO3
13	25-26	Emerging Devices: Introduction to Multi-gate FET Architecture, Structure and Basic Operation of Double Gate MOSFET,	CO4
14	27-28	Emerging Devices: FinFET, Surrounding Gate FET, High-K Dielectric FETs.	CO4

14.36.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.36.8 Text Books and Reference Books

1) Semiconductor Device Fundamentals, Robert F. Pierret, Addison Wesley.

2) Modern Semiconductor Devices for Integrated Circuits, 1st Edition, by Chenming Hu, Pearson India.

3) Solid State Electronic Devices, 7th Edition, B. G. Streetman and B. K. Banerjee, Pearson Higher Education

4) Semiconductor Physics and Devices, 4th Edition, Donald A. Neamen, McGraw-Hill.

14.37 Industrial Management

14.37.1 Introduction of the Course

Course Code and Title: 0413-IPE-3111: Industrial Management.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is a comprehensive course designed to equip students with essential knowledge in different industrial management concepts, techniques and their applications. Throughout this course, students will delve into the intricacies of fundamental management, personnel management, financial management, marketing management, quality management, operations and supply chain management.

Prerequisites (if any): No prerequisite.

14.37.2 Course Objectives

The students are expected to

1) Understand and apply concepts and techniques associated with the primary functional management disciplines.

2) Identify and understand various marketing and financial strategies for the overall supply chain, including demand, procurement, planning, and processes.

3) Understand and design analytical tools to apply cost and management accounting principles in practice.

14.37.3 Course Content

Management: Concept of Management, Definition of Industry from Different Viewpoints, Different View of Management, Management Process Cycle, Characteristics of Management, Different Schools of Management: Bureaucratic School, Administrative School and Scientific Management, Evolution of Management Thought: Classical, Neo Classical and Modern Management Thoughts, Fathers of Management: Max Weber, Henry Fayol and Fredrick Tylor, Industrial Revolution and Development of Management.

Organization: Definition of Organization, Different Types of Organization, Organization as an Open System, Boundary of an Organization, Boundaryless and Virtual Organization, Functions of Manager in an Organization, Different Types of Managers, Span of Control, Authority Delegation, Different Theories Authority, Authority, Responsibility and Accountability.

Human Resource Management: Importance of HRM, Needs Hierarchy Theory by Maslow and other Management and Psychology Experts, Theory of Motivation, Theory of Leadership, Labour Economics and Planning of Wage, Wage and Salary, Exempted and Non Exempted Employees, Different Components of Remuneration, Incentives and Equity in Salary and Wage Salary Compression, Salary Inversion, Internal and External

Equity, Compa Ratio, Employee Turnover, Revenue Employee Ratio, Different Techniques of Performance Appraisal, Change Management.

Operations Management: Evolution of Manufacturing and Production Strategies, Production Planning and Control (PPC) Functions, Quantitative Methods Applied in Production, Location Planning, Layout Planning and Safety Management, Concurrent Engineering, JIT Production, Mass Production, Mass Customization, Lean Manufacturing, Reverse Engineering, Reengineering, Recycling and Refurbishment, Inventory Management, Value Chain Management and Supply Chain Management, Horizontal and Vertical Integration, Economies of Scale and Economies of Scope, Comparative Advantage, Competitive Advantage.

Quality Management: Quality Concept, Quality Assurance, Quality Control, Cost of Quality, Traditional and Taguchi Quality Loss Function, Six Sigma and Kaizen Quality Control System.

Cost and Financial Management: Elements of Cost Products, Cost Analysis, Investment Analysis, and Benefit Cost Analysis, Risk Analysis.

Management Accounting: Cost Planning and Control, Budget and Budgetary Control.

Marketing Management: Different Philosophy of Marketing, Marketing Mix, Sales Promotion, Advertisement, Lead Generation.

Technology Management: Management of Innovation, Technology Assessment, Technology Prediction and Technology Forecasting, Technology Life Cycle, Intellectual Property.

Knowledge Management: Concept of Knowledge, Organizational Knowledge, Explicit and Tacit Knowledge, Organizational Knowledge Management System.

14.37.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the importance of leadership, strategic planning, and management control functions in an industrial organization	PO9	C2	Lecture, Tutorial	Assignment Incourse Final exam
CO2	Develop strategies to manage market, technology, and innovation	PO3	C5	Lecture, Tutorial	Assignment Incourse Final exam
CO3	Apply the financial management-related knowledge to make decisions and to solve	PO2	C3	Lecture, Tutorial	Assignment Incourse Final exam

	problems relevant to productive activities				
CO4	Analyze the performance of organizations/projects quantitatively using different tools and techniques	PO11	C4	Lecture, Tutorial	Assignment Incourse Final exam

14.37.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓			✓	✓	✓	✓								✓	✓	✓

14.37.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Management: Concept of Management, Definition of Industry from Different Viewpoints, Different View of Management, Management Process Cycle, Characteristics of Management, Different Schools of Management: Bureaucratic School, Administrative School and Scientific Management, Evolution of Management Thought: Classical, Neo Classical and Modern Management Thoughts, Fathers of Management: Max Weber, Henry Fayol and Fredrick Tylor, Industrial Revolution and Development of Management.	CO1
3-4	5-8	Organization: Definition of Organization, Different Types of Organization, Organization as an Open System, Boundary of an Organization, Boundaryless and Virtual Organization, Functions of Manager in an Organization, Different Types of Managers, Span of Control, Authority Delegation, Different Theories Authority, Authority, Responsibility and Accountability.	CO1
5-6	9-12	Human Resource Management: Importance of HRM, Needs Hierarchy Theory by Maslow and other Management and Psychology Experts, Theory of Motivation, Theory of Leadership, Labour Economics and Planning of Wage, Wage and Salary, Exempted and Non Exempted Employees, Different Components of Remuneration, Incentives and Equity in Salary and Wage Salary Compression, Salary Inversion, Internal and External Equity, Compa Ratio, Employee Turnover, Revenue Employee Ratio, Different	CO1

		Techniques of Performance Appraisal, Change Management.	
7-8	13-16	Operations Management: Evolution of Manufacturing and Production Strategies, Production Planning and Control (PPC) Functions, Quantitative Methods Applied in Production, Location Planning, Layout Planning and Safety Management, Concurrent Engineering, JIT Production, Mass Production, Mass Customization, Lean Manufacturing, Reverse Engineering, Reengineering, Recycling and Refurbishment, Inventory Management, Value Chain Management and Supply Chain Management, Horizontal and Vertical Integration, Economies of Scale and Economies of Scope, Comparative Advantage, Competitive Advantage.	CO1, CO4
9	17-18	Quality Management: Quality Concept, Quality Assurance, Quality Control, Cost of Quality, Traditional and Taguchi Quality Loss Function, Six Sigma and Kaizen Quality Control System.	CO1
10	19-20	Cost and Financial Management: Elements of Cost Products, Cost Analysis, Investment Analysis, and Benefit Cost Analysis, Risk Analysis.	CO3, CO4
11	21-22	Management Accounting: Cost Planning and Control, Budget and Budgetary Control.	CO3, CO4
12	23-24	Marketing Management: Different Philosophy of Marketing, Marketing Mix, Sales Promotion, Advertisement, Lead Generation.	CO2
13	25-26	Technology Management: Management of Innovation, Technology Assessment, Technology Prediction and Technology Forecasting, Technology Life Cycle, Intellectual Property.	CO2
14	27-28	Knowledge Management: Concept of Knowledge, Organizational Knowledge, Explicit and Tacit Knowledge, Organizational Knowledge Management System.	CO2

14.37.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.37.8 Text Books and Reference Books

1) Lean Production Simplified, 2nd Edition, Pascal Dennis, CRC Press.

2) Industrial Management, 1st Edition, D K Bhattacharyya, Martino Fine Book.

14.38 Microprocessor and Interfacing Laboratory

14.38.1 Introduction of the Course

Course Code and Title: 0714-EEE-3104: Microprocessor and Interfacing Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: In this Microprocessor and Interfacing Lab, theoretical knowledge transforms into hands-on practical skills. This lab course is an integral part of the broader study in Electrical and Electronic Engineering, specifically focusing on developing algorithms and writing assembly language programs. Through hands-on exercises and projects, students gain proficiency in interfacing microprocessors with I/O devices, enhancing their ability to design, implement, and manage complex systems.

Prerequisites (if any): 0714-EEE-2103: Digital Electronics.

14.38.2 Course Objectives

The students are expected to

1) Develop proficiency in assembly language programming for the 8086 microprocessor.

2) Gain practical skills in interfacing microprocessors with various peripherals.

3) Apply project management skills in the context of microprocessor-based systems.

4) Demonstrate proficiency in addressing modes, memory interfacing, interrupts, and I/O interfacing.

14.38.3 Course Content

Experiments in relevance with the EEE 3103 Microprocessor and Interfacing course.

Projects related to EEE 3103 Microprocessor and Interfacing course contents to achieve specific program outcomes.

14.38.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools

CO1	Demonstrate proficiency in assembly Language programming for microprocessors	PO2	C3, A2	Lectures, Coding, Workshop	Assignment, Reports, Lab test, Viva
CO2	Apply interfacing skills to various peripherals	PO2	C4, P4	Lectures, Simulation, Experiment	Lab reports, Hardware demonstrati on, Lab test, Viva
CO3	Execute real-world projects involving microprocessor-based systems	PO11	C6, A4	Workshop, Project	Project report, Presentatio n, Viva
CO4	Demonstrate effective communication of project outcomes	PO10	C2, A4	---	Reports, Presentatio n

14.38.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
		✓			✓	✓		✓	✓		✓		✓		✓	✓		✓	

14.38.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments and projects; Formation of groups/teams for design projects and laboratory works	---
2	Experiment 01	Running assembly code; Programming on console output and input: displaying message, ASCII codes, characters etc. and reading data, numbers, characters, passwords etc.	CO1
3	Experiment 02	Programming on sum of N different numbers, Check whether a number is odd, even, or prime etc.	CO1
4	Experiment 03	Sorting N numbers in ascending/descending order, calculating the largest/smallest number, median from N numbers etc.	CO1

5	Experiment 04	Reversing binary numbers, strings etc., number conversion (binary to hex for example) etc.	CO1
6	Experiment 05	Programming on different arithmetic operations (addition, subtraction, multiplication, division etc.) on different (8-bit/16-bit) signed and unsigned numbers	CO1
7	Experiment 06	Programming on string operations like, finding length of a string, verifying password, inserting or deleting a character/number from a string etc.	CO1
8	Experiment 07	ALP on calling delay subroutine, interfacing keyboard, displaying on 7-segment display etc.	CO1 CO2
9	Experiment 08	Interfacing 8086 microprocessor trainer kit to PC, interfacing and controlling stepper motor	CO2
10	Experiment 09	Interfacing 8251A PCI, 8255A PPI, LCD display, dot-matrix LED etc.	CO2
11	Experiment 10	Interfacing D/A, A/D converters etc.	CO2
12	Project Proposal Presentation	Distribution of projects among different teams; Describe specific technical requirements to be attained during the project	---
13	Project demonstration	Present/demonstrate the technical progress of the project; Describe multidisciplinary aspects of the project	CO3 CO4
14	Final presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence that specific technical requirements have been attained by the project	CO3 CO4

14.38.7 Assessment Pattern/ Strategy

Assessment will be based on the successful execution of assembly language programs, correct interfacing and operation of peripherals, and the completion of comprehensive projects involving microprocessor-based systems.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.38.8 Text Books and Reference Books

1) Microprocessor X86 Programming, K.R. Venugopal and Raj Kumar, BPB Publications.

2) Assembly Language Programming and Organization of the IBM PC, Y. Yu and C. Marut, International Edition, Mitchell McGraw-Hill.

14.39 Communication Systems Laboratory

14.39.1 Introduction of the Course

Course Code and Title: 0714-EEE-3106: Communication Systems Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: The Communication Systems Laboratory course is designed to complement the theoretical knowledge gained in 0714-EEE-3105: Communication Systems course with hands-on, practical experience. In the rapidly advancing field of communication technology, understanding theoretical concepts alone is not sufficient. This laboratory course provides students with the opportunity to apply, experiment, and validate these concepts in a controlled, real-world environment, bridging the gap between theory and practice.

Prerequisites (if any): 0714-EEE-2202: Analog Electronics Laboratory.

14.39.2 Course Objectives

The students are expected to

1) Apply and validate fundamental principles of communication systems through hands-on experiments and projects.

2) Gain proficiency in using modern communication systems tools and instruments, such as oscilloscopes, spectrum analyzers, signal generators, and simulation software.

3) Use simulation software to model, design, and analyze communication systems, ensuring a comprehensive understanding of system behavior under different conditions.

4) Set up and operate analog and digital communication systems, including transmitters and receivers, to understand their design and functionality.

5) Develop problem-solving skills by diagnosing issues in communication systems and optimizing their performance for better reliability and efficiency.

14.39.3 Course Content

Experiments in relevance with the 0714-EEE-3105: Communication Systems course.

Projects related to 0714-EEE-3105: Communication Systems course contents to achieve specific program outcomes.

14.39.4 Course Outcomes (COs)

CO No.	CO Statement	Correspon ding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Reinforce theoretical knowledge by applying and validating	PO1	C1, P1	Lectures, Experiment	Assignment/ reports, Lab test, Viva

	fundamental principles of communication systems through hands-on experiments and projects				
CO2	Develop technical skills in using modern communication systems tools and instruments, such as oscilloscopes, spectrum analyzers, signal generators, and simulation software	PO5	C6, P4	Experiment, Simulation, Project	Lab/project reports, Hardware demonstrati on
CO3	Simulate communication systems ensuring a comprehensive understanding of system behavior under different conditions	PO3	C2, P4, P6	Simulation, Experiment	Lab reports, Hardware demonstrati on, Presentation, Lab test
CO4	Design and operate communication systems using discrete components to understand their design and functionality.	PO3	C6, P7	Experiment, Project, Group discussion	Lab/Project reports, Hardware/ Project demonstrati on, Lab test, Viva
CO5	Develop problem-solving skills by diagnosing issues in communication systems	PO2, PO4	C4, P1	Experiment, Project, Group discussion	Lab/Project reports, Hardware/ Project demonstrati on, Lab test, Viva

14.39.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓	✓		✓	✓			✓	✓		✓			✓	✓	✓			✓

14.39.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments; Formation of groups/teams for design projects and laboratory works	---
2	Experiment 01	Amplitude modulation and demodulation using discrete components.	CO1, CO2, CO4
3	Experiment 02	Simulation of different amplitude modulation/demodulation schemes using MATLAB/Simulink	CO2, CO3
4	Experiment 03	Frequency modulation and demodulation using discrete components.	CO1, CO2, CO4
5	Experiment 04	Simulation of frequency modulation/demodulation schemes using MATLAB/Simulink	CO2, CO3
6	Experiment 05	Simulation of Pulse code modulation and demodulation using MATLAB/Simulink	CO2, CO3
7	Experiment 06	Simulation of different digital modulations and demodulations schemes using MATLAB/Simulink	CO2, CO3
8	Experiment 07	Understanding the operating principle of pre-emphasis and de-emphasis.	CO1, CO2, CO4
9	Experiment 08	To find the characteristics and operations of a compression circuit.	CO1, CO2, CO4
10	Experiment 09	To understand the principles of expander and its characteristics	CO1, CO2, CO4
11	Experiment 10	To find the characteristics and operation of amplitude limiter circuit	CO1, CO2, CO4
12	Lab Final Exam	Show evidence that specific technical skills have been attained by the students	CO2, CO5
13	Project demonstration	Present/demonstrate the technical progress of the project; Describe multidisciplinary aspects of the project	CO2, CO4, CO5
14	Final presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence	CO2, CO4, CO5

		that specific technical requirements have been attained by the project	

14.39.7 Assessment Pattern/ Strategy

Assessment will be based on successful completion of the experimental work, project design, implementation and demonstration of the specific technical skills attained throughout the course.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.39.8 Text Books and Reference Books

1) Modern Analog and Digital Communications, 4th edition by B P Lathi and Zhi Ding.

2) Communication systems, 4th edition by Simon Haykin.

3) Communications System Laboratory, 1st Edition by B. Preetham Kumar.

4) Online resources or supplementary materials will be shared with the class on a need basis.

14.40 Power System I

14.40.1 Introduction of the Course

Course Code and Title: 0713-EEE-3201: Power System I.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is a comprehensive course on power systems focusing on power transmission and including basics on power generation, distribution and protection. This course is designed with tools required to analyze a power system in normal and faulty conditions, modeling of power generators, transmission lines and loads. Knowledge obtained from this course will help students to work directly in any power system industry.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0713 2103: Electromechanical Energy Conversion I, 0713-EEE-2107: Electromechanical Energy Conversion II.

14.40.2 Course Objectives

The students are expected to

1) Learn basic tools used to represent power system and its analysis.

2) Understand modeling of power system components for the purpose of analyzing steady state and dynamic behavior of power systems.

3) Acquire skills in algorithms used to power flow problems.

4) Analyze the power system under normal and faulted conditions for the best operation of the existing power system, for future expansion of the existing power system, and for the planning and design of a new power system.

5) Investigate available control methods when a power system faces abnormal conditions.

6) Learn the basic concepts on relays and circuit breakers used for the power system protection and control.

14.40.3 Course Content

Overview of Modern Power Systems: Generations, Transmissions and Distributions.

Power System Analysis: Phasors, Voltage-Current-Power Relationships in Single/ Three-Phase Systems, Complex Power, Power Triangle, Direction of Power Flow.

Representation of Power Systems: Single-Line Diagram, Per-Unit Methodology.

Modelling Circuit of Power System Components: Transformers, Generators, Loads, Current-Voltage Relationships on Transmission Line: Representation of Lines, Short Transmission Line, Medium-Length Line, Long Transmission Line, Power Flow through a Transmission Line. Steady-State and Dynamic Behavior of Power Systems.

Network Matrices and Power Flow Analysis: Network Matrices, Power Flow Problem, Gauss- Seidel Method, Newton-Raphson Method, Power Flow Studies in System Design and Operation.

Power System Fault Calculations: Symmetrical Components, Symmetrical Faults: Transients in RL Series Circuits, Internal Voltages of Loaded Machines Under Fault Conditions, Fault Calculations using Z-Bus,

Unsymmetrical Faults: Unsymmetrical Faults on Power System, Single Line-to-Ground Faults, Double Line-to-Ground Faults, Open-Conductor Faults, Surge Propagation.

Operation of Power Systems: Distribution of Load between Units within a Plant, Distribution of Load between Plants, Transmission-Loss Equation, Dispatch with Losses.

Basic Principles on Power System Protection and Control.

14.40.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand basic tools to map power systems using one-line diagram for specific purposes of analysis such	PO1	C2, C3	Lectures Discussions Handouts	Assignment Incourse Final Exam

	as load flow or transient analysis				
CO2	Apply knowledge of mathematics and electrical circuits to model power system components	PO3	C2, C3	Lectures Discussions	Assignment Incourse Final Exam
CO3	Understand mathematical tools, complex algorithm, and engineering simulation software for power system analysis	PO5	C2, C3	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO4	Apply models and mathematical tools to analyze power flow problems during normal operation, and fault conditions	PO2	C3, C4	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO5	Explain and compare power flow algorithms, power flow control techniques, and basic protection system for effective and safe operation of the power system	PO4	C3, C5	Lectures Discussions	Assignment Incourse Final Exam

14.40.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓				✓	✓	✓					✓	✓	✓		

14.40.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Overview of Modern Power Systems: Generations, Transmissions and Distributions. Power System Analysis: Phasors, Voltage-Current-Power Relationships in Single/ Three-Phase Systems, Complex Power, Power Triangle, Direction of Power Flow.	CO1
2	3-4	Representation of Power Systems: Single-Line Diagram, Per-Unit Methodology.	CO1
3	5-6	Modelling Circuit of Power System Components: Transformers, Generators, Loads	CO1 CO2
4-5	7-10	Current-Voltage Relationships on Transmission Line: Representation of Lines, Short Transmission Line, Medium-Length Line, Long Transmission Line, Power Flow through a Transmission Line. Steady-State and Dynamic Behavior of Power Systems.	CO1 CO2 CO4
6-7	11-14	Network Matrices and Power Flow Analysis: Network Matrices, Power Flow Problem, Gauss- Seidel Method, Newton-Raphson Method, Power Flow Studies in System Design and Operation.	CO1 CO3 CO4
8-9	15-18	Power System Fault Calculations: Symmetrical Components, Symmetrical Faults: Transients in RL Series Circuits, Internal Voltages of Loaded Machines Under Fault Conditions, Fault Calculations using Z-Bus,	CO1 CO3 CO4
10-11	19-22	Unsymmetrical Faults: Unsymmetrical Faults on Power System, Single Line-to-Ground Faults, Double Line-to-Ground Faults, Open-Conductor Faults, Surge Propagation.	CO1 CO3 CO4
12-13	23-26	Operation of Power Systems: Distribution of Load between Units within a Plant, Distribution of Load between Plants, Transmission-Loss Equation, Dispatch with Losses.	CO1 CO4 CO5
14	27-28	Basic Principles on Power System Protection and Control.	CO1 CO5

14.40.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.40.8 Textbooks and Reference Books

1) Power System Analysis by John J. Grainger and William D. Stevenson, McGraw Hill.

2) Elements of Power System Analysis, William D. Stevenson, McGraw-Hill.

3) Power System Analysis, 3rd Edition, Hadi Saadat, PSA Publication.

4) Modern Power System Analysis, 4th Edition, D P Kothari and I J Nagrath, Tata McGraw Hill Education.

5) Power Systems Analysis, T.K. Nagsarkar and M.S. Sukhija, Oxford University Press.

6) Electric Power Engineering Handbook, Leonard L. Grigsby, CRC Press.

7) Modern Power System Analysis, 2nd Edition, Toran Gonen, CRC Press.

8) Electric Power Principles: Sources, Conversion, Distribution and Use, 1st Edition, James L. Kirtle, Wiley.

9) Power System Analysis and Design, 6th Edition, J. Duncan Glover, Thomas Overbye and Mulukutla S. Sarma, Cengage Learning.

10) Power Systems Analysis, 2nd Edition, Arthur R. Bergen and Vijay Vittal, Pearson.

14.41 Digital Signal Processing

14.41.1 Introduction of the Course

Course Code and Title: 0714-EEE-3203: Digital Signal Processing

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week

Rationale of the Course: This course introduces the fundamental concepts, algorithms, implementations, and practical applications of digital signal processing (DSP) essential for analyzing digital signals and systems. By understanding the core principles, advantages, and applications of DSP, students will develop the skills to design and implement efficient digital systems and filters. The course begins with the analog-to-digital conversion (ADC) process, including its steps, challenges, and practical considerations. It then explores the response of linear time-invariant (LTI) systems using convolution sum and the application of correlation in signal analysis. A detailed study of the discrete Fourier transform (DFT) follows, along with its computational complexity and the efficient realization of DFT using the Fast Fourier Transform (FFT) algorithm. Additionally, the course delves into the z-transform as a mathematical tool for system analysis, covering its role in evaluating causality, stability, and its applications in the design of FIR and IIR digital filters. This course provides students with the opportunity to apply DSP theories to their own fields of interest and serves as a solid foundation for pursuing more advanced topics and applications in digital signal processing.

Prerequisites (if any): 0714-EEE-2109: Signals and Systems

14.41.2 Course Objectives

The Students are expected to:

1) Develop a comprehensive understanding of the core concepts and principles of Digital Signal Processing (DSP) and apply them to analyze and process discrete-time signals and systems.

2) Gain skill in Fourier analysis techniques for discrete-time signals and systems using discrete Fourier transform (DFT), including the implementation of Fast Fourier Transform (FFT) algorithms for efficient frequency-domain analysis.

3) Attain an in-depth understanding of the z-transform and its properties, and apply it to the analysis, stability assessment, and design of linear time-invariant (LTI) systems.

4) Learn to design, implement, and evaluate various types of digital FIR and IIR filters using different design methods and algorithms, while ensuring their stability, performance, and practical applicability in signal processing applications.

14.41.3 Course Content

Introduction: Basic Elements, Advantages and Application Areas of Digital Signal Processing(DSP), Sampling Theorem, Sampling and Quantization of Continuous-Time Signals, Analysis of Finite Word-Length Effects, Overview of Discrete-Time Signals and Systems, Hardware Implementation of Discrete-Time LTI System, Correlation and its Applications in DSP.

Fourier Analysis of Discrete-Time Signals and Systems: Frequency Domain Sampling and Reconstruction of Discrete-Time Signals, The Discrete-Time Fourier Transform, Frequency Resolution of DFT, Properties of DFT, Linear and Circular Convolution using DFT, Frequency Analysis of Signals using the DFT.

Fast Fourier Transform (FFT): Computational Complexity of Direct DFT, FFT Algorithms, Decimation-in-Time FFT, Decimation-in-Frequency FFT, Computational Advantages of FFT, Applications of FFT in Linear Filtering and Correlation, Quantization Effects in the Computation of FFT.

The Z-Transform: The Z-Transform, Properties of Z-Transform, Rational Z- Transform and Time-Domain Behavior of LTI System, Inverse Z-Transform, One-Sided Z-Transform, Solution of Difference Equations, Analysis of LTI Systems in the Z-Domain, Causality and Stability of LTI System in Z-Domain, Frequency Response of LTI System.

Digital Filter Design: Structures of FIR and IIR Filters, Design of FIR Filters using: Windows Method, Frequency Sampling Method, and Chebyshev Approximation Method, Finite Word-Length Effect in FIR Filter,

Design of IIR Filters: Impulse Variant Method, Bilinear Z-Transform Method, Derivatives Approximation Method, Least-Squares Method.

14.41.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Apply the fundamental principles of DSP to analyze and process discrete-time signals and systems, demonstrating a comprehensive understanding of sampling, quantization, and finite word-length effects	PO1, PO2, PO3	C3, C4	Lectures Handouts Discussions	Incourse Final Exam
CO2	Perform and interpret Fourier analysis using the DFT, including the implementation of FFT algorithms, to efficiently analyzing discrete-time signals and systems	PO2, PO4	C3, C4	Lectures Discussions Exercise	Final Exam Assignment
CO3	Utilize the z-transform for the analysis and design of Linear Time-Invariant (LTI) systems	PO2	C3, C4, C5	Lectures Discussions Exercise	Final Exam Assignment
CO4	Design and implement digital FIR and IIR filters, using various design methods and algorithms to solve practical signal processing problems, ensuring stability and optimal performance	PO3, PO5, PO9	C5, C6, P4, P5	Lectures Handouts Discussions	Incourse Final Exam Presentation

14.41.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓	✓	✓	✓	✓			✓		✓				✓	✓		✓		✓

14.41.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction: Basic Elements, Advantages, and Application Areas of Digital Signal Processing (DSP), Sampling Theorem, Sampling and Quantization of Continuous-Time Signals, Overview of Discrete-Time Signals and Systems	CO1
2	3-4	Analysis of Finite Word-Length Effects, Hardware Implementation of Discrete-Time LTI System, Correlation and its Applications in DSP	CO1
3	5	Frequency Domain Sampling and Reconstruction of Discrete-Time Signals	CO1, CO2
3-6	6-12	The Discrete Fourier Transform (DFT), Frequency Resolution of DFT, Properties of DFT, Linear and Circular Convolution using DFT, Frequency Analysis of Signals using the DFT, Computational Complexity of Direct DFT, FFT Algorithms, Decimation-in-Time FFT, Decimation-in-Frequency FFT, Computational Advantages of FFT, Applications of FFT in Linear Filtering and Correlation Quantization Effects in the Computation of FFT.	CO2
7-8	13-16	The z-Transform: Properties of z-Transform, Rational z-Transform, and Time-Domain Behaviour of LTI Systems, Inverse z-Transform, One-Sided z-Transform, Solution of Difference Equations, Analysis of LTI Systems in the z-Domain, Causality and Stability of LTI Systems in z-Domain Frequency Response of LTI Systems	CO3
9-11	17-21	Structures of FIR and IIR Filters, Design of FIR Filters using Windows Method, Design of FIR Filters using Frequency Sampling Method and Chebyshev Approximation Method,	CO4
11-13	22-26	Finite Word-Length Effect in FIR Filters, Design of IIR Filters using Impulse Invariant Method, Bilinear z-Transform Method, Derivatives Approximation Method, Least-Squares Method for IIR Filter Design, Ensuring Stability and Optimal Performance	CO4
14	27-28	Real-World Case Studies: Implementation of Digital FIR and IIR Filters	CO1, CO4

14.41.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentations are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.41.8 Text Books and Reference Books

1) Digital Signal Processing - Principles, Algorithms and Applications, 3rd Edition, John G. Proakis and Dimitris G. Manolakis, Prentice-Hall International, Inc.

2) Digital Signal Processing-A Practical Approach, 3rd Edition, Emmanuel C. Efeacher and Barrie W. Jervis, Prentice-Hall

3) Digital Signal Processing-A Computer based Approach, 3rd Edition, Sanjit K. Mitra, Mc-Graw Hill.

4) Discrete-Time Signal Processing, 2nd Edition, Alan V. Oppenheim, Alan W. Schafer and John R. Buck, Prentice-Hall.

14.42 Materials Science

14.42.1 Introduction of the Course

Course Code and Title: 0714-EEE-3205: Materials Science.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with an in-depth understanding of the fundamental principles and advanced concepts of materials science, focusing on the thermal, electrical, dielectric, optical, magnetic, and superconducting properties of materials. Through comprehensive exploration of theoretical models and experimental techniques, students will develop the skills necessary to analyze and manipulate the properties of various materials for applications in engineering and technology.

Prerequisites (if any): 0533-PHY-1201: Modern Physics, 0533-PHY-1203: Optics, 0531-CHE-1207: Chemistry, 0714-EEE-2105: Solid State Physics, 0715-MEC-2205: Fundamentals of Mechanical Engineering.

14.42.2 Course Objectives

The students are expected to

1) Understand and apply the fundamental principles governing the thermal properties of solids, and the electrical, dielectric, optical and magnetic properties of materials.

2) Explore the principles of superconductivity and their implications in material science.

3) Understand the basic concepts of nonlinear optics and their applications.

14.42.3 Course Content

Thermal Properties: Specific Heat of Solid- Dulong-Petit Law, Boltzmann, Einstein and Debye Models of Specific Heat, Thermal Expansion of Solid, Effect of Non-Harmonic Potential, Heat Conduction by Phonons, Thermal Conductivity of Materials, Thermionic Emission.

Electrical Properties: The Drude Theory of Metal, Classical DC and AC Electrical Conductivity, Hall Effect and Magnetoresistance, Quantum Mechanical Corrections to Electrical Conductivity.

Dielectric Properties: Macroscopic Maxwell's Equation, Theory of Local Field, Clausius-Mossotti Equation, Dielectric Constant and Polarizability, Ferro-electric, Anti-ferroelectric, Piezoelectric Materials.

Optical Properties: Optical Processes, Optical Coefficients, The Complex Refractive Index and Dielectric Constant, The Lorentz Dipole Oscillator Model, Excitons and its Binding Energy, Interband Luminescence, Photo Luminescence, Electroluminescence.

Magnetic Properties: Magnetic Moments and Angular Momentum, The Bohr Magneton, Magnetic Susceptibility, Classical Diamagnetism, Langevin Paramagnetism, Ferrimagnetism, Ferromagnetism and Antiferromagnetism.

Superconductivity: Superconducting Material, Zero Resistivity, The Meissner-Ochsenfeld Effect, Perfect Diamagnetism, Type I and Type II Superconductivity, The London Equation.

Nonlinear Optics: Nonlinear Optical Processes, Nonlinear Susceptibility, Anharmonic Oscillator, Phase Matching, Sum and Difference Frequency Generation, Second Harmonic Generation.

14.42.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Apply the fundamental principles governing the thermal properties of solids and electrical properties of materials	PO1, PO2	C3	Lectures Handouts Discussions	Incourse Final Exam

CO2	Analyze and interpret the dielectric and optical properties of materials using theoretical models	PO1, PO2, PO4	C4	Lectures Handouts Discussions	Assignment Final Exam
CO3	Investigate the magnetic properties of materials and explore the principles of superconductivity	PO1, PO2, PO4	C4	Lectures Handouts Discussions	Presentation Final Exam
CO4	Understand and apply the basic concepts of nonlinear optics and their applications in material science	PO1, PO12	C5	Lectures Handouts Discussions	Incourse Presentation Final Exam

14.42.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓					✓		✓					✓				✓

14.42.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Boltzmann Solid, Dulong-Petit Law of Specific Heat, Einstein Model of Specific Heat: Atoms as Independent Harmonic Oscllilators, Debye Modifications to Specific Heat: Interacting Harmonic Oscillators.	CO1
2	3-4	Anharmonic Modeling of Atomic Vibrations, Thermal Expansion, Heat Conduction by Phonon, Classical Model of Thermal Conductivity, Work function of Materials, and Thermionic Emission.	CO1
3	5-6	Postulates of Drude Model, Static and High Frequency Electrical Conductivity, Charge Carrier Motion in Magnetic Field and Hall Effect.	CO1

4	7-8	Magnetoresistance, Fermi-Dirac Distribution, Treating Electrons as Fermions, Fermionic Correction to Electrical Conductivity.	CO1
5	9-10	Microscopic and Macroscopic Maxwell's Equations, The Lorentz Model of Local Field, Estimation of Polarizability and Clausius-Mossotti Equation.	CO2
6	11-12	The Kramers–Kronig Relations, Complex Dielectric Constant, Spontaneous Polarizability, The Emergence of Ferroelectric Phase in Material, Ferroelectric Hysteresis, Concept of Multiferroic Order in Material.	CO2
7	13-14	Optical Processes in Materials, Defining Optical Properties via Optical Coefficients, Complex Refractive Index, Optical Response of Free and Bound Electrons in Materials.	CO2
8	15-16	Modeling Various Optoelectronic Transition, Formation of Exciton, Binding Energy Calculation of Excitation, Modeling the Photoluminescence and Electroluminescence.	CO2
9	17-18	The Origin of Magnetism: Nuclear and Electronic Origin, Quantum Mechanical Operators for Magnetic Moments and Spin and Orbital Angular Momentum, Model Hamiltonian for Atomic Magnetism.	CO3
10	19-20	Quantum Mechanical Model of Atomic Diamagnetism, Pauli and Langevin Paramagnetism, Spontaneous Magnetism: Ferromagnetism, Ferrimagnetism, and Antiferro Magnetism.	CO3
11	21-22	The Origin of Finite Conductivity: Scattering Mechanisms, The Emergence of Infinite Conductivity, The Concept of Persistent Current, The Meissner-Ochsenfeld Effect, and Perfect Diamagnetism in Superconducting State.	CO3
12	23-24	Characteristics of Type I and Type II Superconductors, The London Theory of Superconductivity, Concept of Coherence Length, Cooper Pair Formation, The Vortex Formation in Type II Superconductors	CO3
13	25-26	Nonlinear Optical Processes, Nonlinear, Physical Origin of Nonlinearity, Susceptibility Tensor, Non-linear Maxwell's Equation, Anharmonic Oscillator and Non-linear Models, Coupled Differential Equations.	CO4
14	27-28	Nonlinear Crystal, Phase Matching, Sum and Difference Frequency Generation, Second Harmonic Generation, Parametric Down Conversion, Kerr Effect	CO4

14.42.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.42.8 Text Books and Reference Books

1) Solid State Physics, 1st Edition, Neil W. Ashcroft and N. David Mermin, Cengage Learning.

2) The Oxford Solid State Basics, 1st Edition, Steven H. Simon, Oxford University Press.

3) Introduction to Solid State Physics, 8th Edition, Charles Kittel, Wiley.

4) Electronic Properties of Materials 4th Edition, Rolf E. Hummel, Springer.

5) Optical Properties of Solids, 2nd Edition, Mark Fox, Oxford University Press.

6) Magnetism in Condensed Matter, Paperback, Stephen Blundell, Oxford University Press.

7) Superconductivity, Superfluids, and Condensates, 1st Edition, James F. Annett, Oxford University Press.

8) Nonlinear Optics, 3rd Edition, Robert W. Boyd, Academic Press.

14.43 Optoelectronics and Photonics

14.43.1 Introduction of the Course

Course Code and Title: 0714-EEE-3207: Optoelectronics and Photonics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The course is designed to provide a comprehensive understanding of the fundamental principles of optoelectronic devices and their applications. The course aims to equip students with the knowledge and skills necessary to analyze, design, and implement different optoelectronic devices. Furthermore, the curriculum recognizes the practical importance of these devices in key sectors, such as low power light industry, optical communication, in medical and scientific instrumentation and eco-friendly power generation sectors. This course will help students develop a strong foundation for advanced optoelectronics and photonics engineering fields.

Prerequisites (if any): 05331203: Optics, EEE-2105: Solid State Physics, 0714-EEE-3109: Electronic Devices.

14.43.2 Course Objectives

The students are expected to

1) Acquire knowledge about the fundamentals of light propagation and its properties in different medium and at the interface.

2) Understand the physics of semiconductor light source such as LED and LASER; Photodetectors such as PIN and APD; Photo sensors, Phototransistors and Solar cell. To have clear idea about the challenges that exists in achieving better device performances.

3) Study and analyze state-of-the-art optoelectronic devices and their developments.

4) Learn about the significant impact of these devices in fourth industrial revolution (4IR) and also in achieving two major elements of the Sustainable Development Goals (SDGs) set by UN as i) affordable and clean energy and ii) climate action.

14.43.3 Course Content

Nature and Properties of Light: Optical Spectra of Atoms, Molecules, and Solids, Refractive Index, Negative Refractive Index of Metamaterials, Quantum Nature of Light and Matter, Light Matter Interaction at Nanoscale, Diffraction of Light, Wave Optics and Gaussian Beams.

Optical Properties in Semiconductor and LED: Direct and Indirect Band-Gap Materials, Radiative and Non-Radiative Recombination, Optical Absorption, Photo-Generated Excess Carriers, Minority Carrier Lifetime, Luminescence and Quantum Efficiency in Radiation, Principles of LED, Materials for LED, Internal and External Efficiency, Loss Mechanism, Structure and Coupling to Optical Fibers, White LED Technologies.

Semiconductor Lasers: Spontaneous and Stimulated Emission, Einstein Relations, Gas Lasers and Applications, Theory of Laser Oscillation, Characteristics of Laser Output, Hetero-Junction Lasers, Introduction to Quantum Well Lasers, Single Frequency Solid State Lasers, VCSELs.

Photo-Detectors: PN Junction Photodiode, PIN Photodiode, Avalanche Photodiodes, Heterojunction Photodiodes and Phototransistors.

Solar Cells: Solar Energy and Spectrum, Photovoltaic Device Principles, I-V Characteristics, Equivalent Circuit, Thin Film Solar Cell, Solar Cells Materials, Devices and Efficiencies, Heterojunction Solar Cell, Tandem Solar Cell.

Introduction to Photonics: Ring Resonators, Optical Couplers, Photonic Crystal and Guided Optics, Silicon Photonics, Basic Principles of Holography.

14.43.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Acquire knowledge about the fundamentals	PO1	C1	Lectures Discussions Exercise	Assignment In-course Final Exam

	of light propagation and its properties			Handouts	
CO2	Understand the physics of semiconductor optoelectronics devices	PO1	C1	Lectures Discussions Exercise Handouts	Assignment In-course Final Exam
CO3	Study and analyze the optoelectronic devices, their limitation and developments	PO2, PO4	C2, C4	Lectures Exercise Handouts	Assignment In-course Final Exam
CO4	Analyze the impact of optoelectronic and photonic devices on the 4IR, focusing on their roles in achieving the SDGs	PO7	C3	Lectures Exercise Discussions	Assignment In-course Final Exam

14.43.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓			✓	✓	✓	✓						✓	✓			

14.43.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Optical Spectra of Atoms, Molecules, and Solids, Refractive Index, Negative Refractive Index of Metamaterials, Quantum Nature of Light and Matter, Light Matter Interaction at Nanoscale, Diffraction of Light, Wave Optics and Gaussian Beams	CO1
3-4	5-8	Direct and Indirect Band-Gap Materials, Radiative and Non-Radiative Recombination, Optical Absorption, Photo-Generated Excess Carriers,	CO1
5-6	9-12	Minority Carrier Lifetime, Luminescence and Quantum Efficiency in Radiation, Principles of LED, Materials for LED, Internal and External Efficiency, Loss Mechanism, Structure and Coupling to Optical Fibers, White LED	CO1-CO4

		Technologies.	
7-8	13-16	Spontaneous and Stimulated Emission, Einstein Relations, Gas Lasers and Applications, Theory of Laser Oscillation, Characteristics of Laser Output	CO1, CO2,
9-10	17-20	Hetero-Junction Lasers, Introduction to Quantum Well Lasers, Single Frequency Solid State Lasers, VCSELs.	CO2-CO4
11-12	21-23	PN Junction Photodiode, PIN Photodiode, Avalanche Photodiodes, Heterojunction Photodiodes and Phototransistors.	CO2-CO4
12-13	24-26	Thin Film Solar Cell, Solar Cells Materials, Devices and Efficiencies, Heterojunction Solar Cell, Tandem Solar Cell.	CO2-CO4
14	27-28	Ring Resonators, Optical Couplers, Photonic Crystal and Guided Optics, Silicon Photonics, Basic Principles of Holography	CO1, CO2

14.43.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Students will be assigned home tasks or assignments on regular basis. The assignment should be submitted within one week from the assign date.

3) In-course: There will be a minimum 1 in-course exam; if 2 or more in-course exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.43.8 Text Books and Reference Books

1) Optoelectronics & Photonics: Principles & Practices, 2nd Edition, S. O. Kasap, Pearson.

2) Fundamentals of Photonics, 2nd Edition, B. E. A. Saleh and M. C. Teich, John Wiley and Sons.

3) Optics, E. Hecht and A. Zajac, 3rd Edition, Addison-Wesley.

4) Light-Matter Interaction: Physics and Engineering at the Nanoscale, 2nd Edition, John Weiner, Oxford University Press.

5) Nanoscale Photonics and Optoelectronics, Zhiming M. Wang and Arup Neogi, Springer.

14.44 Communication Theory

14.44.1 Introduction of the Course

Course Code and Title: 0714-EEE-3209: Communication Theory.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The communication of data and signals is part and parcel of everyday life. Whether the communication is through a physical channel or a wireless channel, there are some inevitable constraints that, if not addressed, will make the communication of data or signals untenable. Therefore, this B.Sc. level Communication Theory course is one of the foundational courses in the department of Electrical and Electronic Engineering. This course is designed to equip students with theoretical concepts needed to design, analyze, and optimize communication systems.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0541-MAT-1105: Differential and Integral Calculus.

14.44.2 Course Objectives

The Communication Theory course is designed to provide students with a strong foundation in the principles and applications of communication systems. This course mainly focuses on the spectral analysis of signals and the minimization of noise accompanied by the signal.

The students are expected to

1) Perform spectral analysis of signals and noise.

2) Identify the effects of a linear time-invariant (LTI) systems on signal and noise power.

3) Analyze the problems in baseband digital transmission and methods of overcoming them.

4) Introductory understanding of cellular communication.

14.44.3 Course Content

Spectral Analysis: Fourier Series, The Sampling Function, Response of a Linear System, Normalized Power, Normalized Power in a Fourier Expansion, Power Spectral Density, The Fourier Transform, Convolution, Parseval's Theorem, Correlation between Waveforms, Autocorrelation.

Random Variables and Processes: Probability, Cumulative Distribution Function, Probability Density Function, Tchebycheff's Inequality, The Gaussian Probability Density, The Error Function, The Rayleigh Probability Density, Correlation Between Random Variables, The Central-Limit Theorem, Random Processes, Autocorrelation, Power Spectral Density of a Sequence of Random Pulses, Power Spectral Density of Digital Data, Effect of Rudimentary Filters on Digital Data, The Complimentary Error Function.

Mathematical Representation of Noise: Some Sources of Noise, A Frequency- Domain Representation of Noise, Spectral Components of Noise, Response of a Narrowband Filter to Noise, Effect of a Filter on the Power Spectral Density of Noise, Superposition of Noises, Mixing Involving Noise, Linear Filtering, Noise Bandwidth, Quadrate Components of Noise, Power Spectral Density of $N_C(T)$ and $N_S(T)$, Probability Density of $N_C(T)$ and $N_S(T)$, and their Time Derivatives.

Communication System and Noise Calculations: Resistor Noise, Multiple Resistor Noise Sources, Networks with Reactive Elements, Available Power, Noise Temperature, Two Ports, Noise Bandwidth, Effective Input-Noise Temperature, Noise Figure, Noise Figure and Equivalent Noise Temperature of a Cascade, Example of a Receiving System, Antennas, System Calculation.

Information Theory: Discrete Message, The Concept of Amount of Information, Average Information, Entropy, Information Rate, Coding to Increase Average Information per Bit, Mutual Information, Shannon's Theorem, Channel Capacity, Capacity of a Gaussian Channel, Bandwidth-S/N Trade-off, Use of Orthogonal Signals to Attain Shannon's Limit, Efficiency of Orthogonal Signal Transmission.

Baseband Digital Transmission: Limitations, Pulse Shaping, Repeaters, Inter Symbol Interference (ISI), Pulse Equalization Techniques, Nyquist Criterion for Zero ISI, Delay in Detection, Fixed Equalizer, Design of Equalizer, Adaptive Equalizer, AWGN Channel Model, Bit Error Rate of a Baseband Transmission System, Channel Capacity Theorem, Coherent Reception, Digital Receivers, Matched Filter and Correlation Receiver, Bit Error Rate Calculation of a Digital Link, Digital Link Design.

Wireless Digital Communication System: Wireless Channel Model, Noncellular and Cellular Communication, Cellular Concept, Frequency Reuse Techniques, and Introduction to Mobile Communication Systems.

14.44.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Identify signals and systems and apply Fourier series and transform for spectral analysis of signals.	PO1	C1, C2, C3, P1, P3	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO2	Understand and analyze the behavior of random signals and noise.	PO1, PO2	C1, C2, P1, P2	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO3	Understand information theory. Analyze and design source coding for the reduction of error.	PO1, PO3	C1, C2 C3, P1, P3	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO4	Analyze baseband transmission	PO2	C1, C4, P1, P2	Lectures, Discussions,	Assignment, Presentation,

	mode of digital data and basics of cellular communications.			Handout	Class work

14.44.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓					✓	✓						✓	✓			

14.44.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction and instructions, orientation, objectives and prerequisite, ac waveforms, phasors and line spectrum, different types of signals and examples.	CO1
2	3-4	Types of systems, singularity functions, introduction to spectral analysis, trigonometric form of Fourier series, Dirichlet conditions for Fourier series, exponential form of Fourier series.	CO1
3	5-6	Fourier series representation of a train of pulses, sampling function, Fourier transform, Phase and magnitude spectrum of Fourier transform, Fourier transform theorems. Parseval's power theorem, Parseval's relation and Parseval's identity or Parseval's theorem, normalized power in a Fourier expansion, power spectral density, orthogonality of two cosine functions cos nx and cos mx.	CO1
4	7-8	Operations on signals, convolution and convolution theorem, graphical interpretation of the convolution integral. Correlation (or cross-correlation), power and cross-correlation, effect of transfer function on power spectral density, autocorrelation, autocorrelation of a periodic waveforms, the correlation function of a periodic waveforms and its power spectral density.	CO1
5	9-10	Autocorrelation of a nonperiodic waveform of finite energy, characterizing LTI system, transfer function, system response to an exponential function, distortionless transmission, effect of transfer function on PSD.	CO1
6	11-12	Probability, mutually exclusive events, joint probability of related and independent events – Bayes theorem, statistical independence, random variables, cumulative	CO2

		distribution function, probability density function, relation between probability and probability density function, joint cumulative distribution and probability density, average value of a random variable, variance of random variable, Gaussian (or normal) probability density function. Cumulative Gaussian probability – the error function, probability calculation example, the Rayleigh probability density.	
7	13-14	Means and variance of the sum of random variables, probability density of sum of random variables, correlation between random variables and example, the central limit theorem, Tchebycheff's inequality. Introduction to random processes, random processes, difference between random variables and processes, autocorrelation and power spectral density of a sequence of random pulses, power spectral density of a digital data, effects of first order R-C, R-L filters and digital data.	CO2
8	15-16	Introduction to mathematical representation of noise, some sources of noise, frequency – domain representation of noise, spectral components of noise, response of a narrowband filter to noise. Effect of filter on PSD of noise, superposition of noises, mixing noise with sinusoid, mixing noise with noise, linear filtering of noise, the RC low-pass filter, the rectangular (ideal) low-pass filter, a differentiating filter, an integrator.	CO2
9	17-18	Noise bandwidth, quadrature components of noise, power spectral density of quadrature components, example, probability density of quadrature components and time derivatives.	CO2
10	19-20	Introduction to information theory, discrete messages and information content, the concept of amount of information, average information – entropy, information rate, source coding to increase average information per bit, Shannon-Fano coding, Huffman coding, Lempel-Ziv (LZ) coding. Shannon's theorem, capacity of a Gaussian channel, bandwidth – S/N trade off, use of orthogonal signal transmission, matched – filter reception, calculation of error probability.	CO3
11	21-22	Introduction to communication system and noise calculation, resistor noise, multiple resistor noise sources, networks with reactive elements – an example, an application to RC circuit, available power, noise temperature, two ports, available gain, noise bandwidth, effective input noise temperature.	CO2

		Noise figure, equivalent noise temperature of a cascade, an example of a receiving system, antennas, system calculation example, an example of a satellite – to – Earth communication system.	
12	23-24	Baseband and pass-band systems, limitations of baseband digital transmission, pulse shaping in baseband digital transmission, Nyquist criterion for zero inter symbol interference, inter symbol interference (ISI), Nyquist's criterion for distortionless baseband binary transmission, ideal nyquist channel.	CO4
13	25-26	Delay in detection, fixed equalizer, design of equalizer, adaptive equalizer, AWGN channel model, bit error rate of a baseband transmission system, channel capacity theorem, coherent reception, digital receivers, matched filter and correlation receiver, bit error rate calculation of a digital link, digital link design.	CO4
14	27-28	Introduction to digital communication system, wireless channel model, non-cellular and cellular communication, cellular concept, frequency reuse techniques, introduction to mobile communication systems.	CO4

14.44.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.44.8 Text Books and Reference Books

1) Probability and Random Processes, Geoffrey Grimmett and David Stirzaker, Oxford University Press.

2) Probability, Random Processes, and Estimation Theory for Engineers, Stark &Woods, Prentice Hall.

3) Probability, Statistics, and Random Processes for Electrical Engineering, Leon-Garcia, Addison-Wesley.

4) Elements of Information Theory, T M Cover & J A Thomas, Wiley.

5) Signal Processing and Detection, John Cioffi.

6) Modulation and Coding for Wireless Communications, Burr A, Prentice Hall.

7) Digital Communications Fundamentals and Applications, Sklar B, Prentice Hall.

8) Digital Communications, I. A. Glover & P.M. Grant, Prentice Hall.

9) Introduction to Digital Communications, R.E. Ziemer & R.L. Peterson, MacMillan.

10) Wireless Communications, Andre Goldsmith, Cambridge University Press.

11) Communication Systems, 4th Edition, Simon Haykin, Wiley.

12) Digital Communications Systems, 1st Edition, Simon Haykin, Wiley.

13) Wireless Communications: Principles and Practice, 2nd Edition, Theodore S. Rappaport, Prentice Hall.

14) Communication Systems Engineering, 2nd Edition, John G. Proakis and Masoud Salehi, Pearson.

15) Probability, Random Variables and Stochastic Processes, 4th Edition, Athanasios Papoulis and S. Unnikrishna Pillai, McGraw-Hill Europe.

16) Principles of Communications: Systems, Modulation, and Noise, 4th Edition, Rodger E. Ziemer and W. H. Tranter, Wiley.

17) Modern Digital and Analog Communication Systems, 4th Edition, B.P. Lathi, Zhi Ding and Hari Mohan Gupta, Oxford University Press.

18) Principles of Communication Systems, 4th Edition, Herbert Taub, Donald Schilling and Goutam Saha, McGraw-Hill Education.

14.45 Financial Accounting and Cost Management

14.45.1 Introduction of the Course

Course Code and Title: 0411-GED-3211: Financial Accounting and Cost Management.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: In an era of increasing financial complexity, engineering professionals need a strong foundation in financial accounting and cost management to make informed decisions in project planning, resource allocation, and cost control. This course equips engineering students with essential financial knowledge and skills to understand accounting principles, analyze financial statements, and apply cost management techniques to optimize resources and enhance operational efficiency. By integrating financial acumen with engineering expertise, students can contribute to the sustainable growth and financial stability of engineering projects and organizations.

Prerequisites (if any): No prerequisite.

14.45.2 Course Objectives

The students are expected to

1) Understand the fundamental principles of financial accounting and its relevance in organizational decision-making.

2) Develop the ability to prepare and analyze financial statements to evaluate the financial health of an organization.

3) Gain insights into cost and management accounting techniques for effective planning, control, and decision-making in engineering contexts.

4) Apply cost analysis methods to optimize project costs and improve financial performance.

5) Understand and implement financial strategies for long-term investment, capital budgeting, and risk management.

14.45.3 Course Content

Financial Accounting: Objectives and Importance of Accounting, Purpose of Accounting, Branches of Accounting, Accounting as an Information System, Accounting standards GAAP, Need for Integrity in the field of Accounting, Double Entry Mechanism, Accounts and their Classification, Basic Accounting Equation, Accounting Cycle, Journal, Ledger, Trial Balance, Need for Financial Statement, Four Basic Financial Statements: Income Statement, Cash Flow, Balance Sheet, Stake Holders Equity, Preparation of Financial Statements, Financial Statements Analysis and Interpretation: Horizontal and Vertical Analysis, Ratio Analysis: Calculation of Different Financial Ratios and their Significance, Project Financing, Financial Market, Financial Instruments.

Cost and Management Accounting: Introduction to Cost and Management Accounting, Objectives and Scope of Cost and Management Accounting, Functions of Management Accounting, Relationship of Cost Accounting, Financial Accounting, Management Accounting and Financial Management, Limitations of Financial Accounting, Cost Concept and Classification, Cost Segregation, Methods of Cost Segregation: Two-Point Method, Least Square Method, Cost Estimation, Accounting for Materials, Accounting for Labour Cost, Accounting for Overhead Cost, Costing in Different Situations: Service Costing, Job Order Costing, Process Costing, Joint Product and By-Product Costing, Accounting for Profit Planning: Absorption Costing, Variable Costing, Reconciliation of Profit/Loss, Cost–Volume Profit Analysis, Cost Accounting for Planning and Control: Standard Costing, Variance Analysis, Budgeting for Planning, Flexible Budgeting, Cost Reduction: Cost Reduction and Cost Control, Value Engineering, Value Analysis.

Decisions: Relevant and Differential Cost Analysis, Linear Programming, Long- Term Investment Decisions: Capital Budgeting, Various Techniques of Evaluation of Capital Investment, Investment Appraisal under Uncertainty, Risk Management, Capital Rationing, Working Capital Management, Fund Flow Statement and Sources and Uses of Funds, Cash Flow Statement and Management of Cash, Stock Debtors, Management of Profits/Dividend Policy.

14.45.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools

CO1	Demonstrate an understanding of financial accounting principles, standards, and the double-entry mechanism to prepare and interpret financial statements.	PO1, PO2, PO10	C2	Lectures Handouts Discussions	Incourse Final Exam
CO2	Apply financial statement analysis techniques to assess organizational performance and inform decision-making.	PO2, PO4, PO11	C4	Lectures Discussions Exercise	Final Exam Assignment
CO3	Utilize cost management tools to optimize resource utilization and control costs.	PO1, PO2, PO5	C3	Lectures Discussions Exercise	Final Exam Assignment
CO4	Analyze and evaluate long-term investment decisions using techniques like capital budgeting, risk analysis, and cash flow management.	PO3, PO11, PO12	C6	Lectures Handouts Discussions	Incourse Final Exam Assignment
CO5	Develop practical financial strategies for working capital management, cost reduction, and value engineering in engineering projects.	PO5, PO10, PO12	C5	Lectures Discussions Exercise	Final Exam Assignment Presentation

14.45.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓					✓						✓	✓		✓			✓	

14.45.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-2	Objectives and Importance of Accounting, Purpose of Accounting, Branches of Accounting Accounting as an Information System, Accounting Standards (GAAP), Need for Integrity in Accounting	CO1
2	3-4	Double Entry Mechanism, Accounts and their Classification, Basic Accounting Equation Accounting Cycle, Journal, Ledger, and Trial Balance	CO1
3	5-6	Need for Financial Statements, Introduction to Four Basic Financial Statements (Income Statement, Cash Flow, Balance Sheet, Stakeholders' Equity) Preparation of Financial Statements	CO1
4	7-8	Financial Statement Analysis and Interpretation: Horizontal and Vertical Analysis Ratio Analysis: Calculation of Different Financial Ratios and Their Significance	CO2
5	9	Project Financing, Financial Market, and Financial Instruments	CO2, CO4
5-6	10-12	Introduction to Cost and Management Accounting, Objectives and Scope Functions of Management Accounting, Relationship with Financial Accounting and Financial Management Cost Concepts and Classification, Methods of Cost Segregation: Two-Point and Least Square Methods	CO3
7-8	13-16	Accounting for Materials, Labour Cost, and Overhead Costs Costing in Different Situations: Service, Job Order, and Process Costing Joint Product and By-Product Costing Accounting for Profit Planning: Absorption Costing and Variable Costing	CO3
9	17-18	Reconciliation of Profit/Loss, Cost–Volume Profit Analysis Cost Accounting for Planning and Control: Standard Costing and Variance Analysis	CO3, CO4
10	19-20	Budgeting for Planning, Flexible Budgeting, and Cost Reduction Value Engineering and Value Analysis	CO3, CO4, CO5

11	21-22	Relevant and Differential Cost Analysis Linear Programming Applications in Cost and Financial Management	CO4, CO5
12	23-24	Long-Term Investment Decisions: Capital Budgeting Techniques Investment Appraisal under Uncertainty, Risk Management, and Capital Rationing	CO4
13-14	25-28	Working Capital Management, Fund Flow Statements, and Sources and Uses of Funds Cash Flow Statement and Management of Cash Stock Debtors, Management of Profits, and Dividend Policy	CO4, CO5

14.45.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.45.8 Text Books and Reference Books

1) Cost Accounting, 3rd Edition, Ralph S. Polimeni, Frank Fabozzi and Arthur H. Adelherg, McGraw Hill.

2) Managerial Accounting, 10th Edition, R.H. Garrison, McGraw Hill.

3) Financial Accounting, Wyane Thomas, 4th Edition, McGraw-Hill Education.

14.46 Power System I Laboratory

14.46.1 Introduction of the Course

Course Code and Title: 0713-EEE-3202: Power System I Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: In this Power System I laboratory, the theoretical knowledge transforms into practical skills. The students will model equipment in power systems and test their performance. Students will learn algorithms and their programming and implement them in analyzing power systems.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0713 2103: Electromechanical Energy Conversion I, 0713-EEE-2107: Electromechanical Energy Conversion II.

14.46.2 Course Objectives

The students are expected to

1) Understand the concepts of reactive power and power factor correction so that they can apply these principles in real-world AC circuit scenarios.

2) Model power transmission lines and perform performance analysis so that they can effectively analyze and optimize power transmission systems.

3) Form the bus admittance matrix of a power grid and conduct load flow so that they can solve power flow problems and design efficient power distribution networks.

4) Conduct fault analysis and explore voltage regulation techniques so that they can enhance the stability and reliability of power systems under various fault conditions.

5) Prepare and present project proposals, conduct hands-on experiments, and demonstrate their projects, including a visit to a substation and a power plant.

14.46.3 Course Content

Experiments in relevance to the 0713-EEE-3201: Power System I course.

Projects related to 0713-EEE-3201 Power System I course contents to achieve specific program outcomes.

14.46.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Design a power factor correction (PFC) plant using engineering tools and software and analyze its behavior upon load changes, and also investigate a real PFC plant	PO1, PO3, PO4, PO5	C2, C4, C6, P4	Lectures, Hands on experience on simulation tools, Laboratory Experiment, Discussions	Assignment/ reports, Lab performance Viva, Project, Final Quiz
CO2	Apply the knowledge of transmission lines to model equivalent circuits of	PO1, PO2, PO3, PO4, PO5	C2, C3, C4	Lectures, Hands on experience on simulation tools,	Assignment/ reports, Lab performance Viva, Final Quiz

	different lengths, generators and loads, and analyze their performance at different loading conditions using engineering tools and software			Laboratory Experiment, Discussions	
CO3	Use power system analysis tools for steady-state load flow study and fault synthesis, and to investigate the effect on the power system when some part of it is modified, and design required system upgradation	PO1, PO2, PO3, PO5	C2, C4, C5, C6	Lectures, Hands on works using simulation tools, Laboratory Experiment, Discussions	Assignment/ reports, Lab performance Viva, Final Quiz.
CO4	Understand the layout and operation of a substation and a power plant, design and implement power system controller and observe their performances	PO1, PO3, PO4	C2, C3, C6	Lectures, Laboratory Experiment, Discussions	Assignment/ reports, Lab performance Viva, Final Quiz.
CO5	Demonstrate project management and cost analysis for power system element design project	PO11	A3	----	Presentation and project report

14.46.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		

14.46.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introductory discussions on the experiments and projects; formation of teams for laboratory works and design projects	---
2	Experiment 1	(i) Understanding of reactive power and power factor correction in ac circuits (ii) Experiment with microprocessor-based PFC plant	CO1
3	Experiment 2	Modeling and performance analysis of power transmission lines	CO2
4	Experiment 3	Investigation of complex power flow between two active sources	CO2
5	Experiment 4	Formation of Bus admittance matrix of a power grid	CO3
6	Experiment 5	Gauss-Seidel Load flow analysis using MATLAB software	CO3
7	Experiment 6	Power system load flow analysis with Newton-Raphson method	CO3
8	Experiment 7	Voltage regulation using OLTC and capacitor bank	CO4
9	Project proposal presentation	Describe specific technical requirements to be achieved in the project	---
10	Experiment 8	Representation and synthesis of a three-phase unbalanced system by equivalent three balanced systems using symmetrical components	CO3
11	Experiment 9	Symmetric and unsymmetric fault analysis using MATLAB Simulink models	CO3
12	Industry Visit	Visit to a substation and a power plant	CO5
13	Project demonstration	Project demonstration in the form report presentation and practical	CO5
14	Final evaluation	Final viva, written quiz, and lab test	CO1-CO5

14.46.7 Assessment Pattern/ Strategy

Assessment will be based on successful modeling and performance testing, successful scripting and execution of programming language for power system analysis, hardware test and completion of a comprehensive project on power system and its equipment.

Distribution of marks:

Class Attendance	10%

Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.46.8 Textbooks and Reference Books

1) Power System Analysis by John J. Grainger and William D. Stevenson, McGraw Hill.

2) Elements of Power System Analysis, William D. Stevenson, McGraw-Hill.

3) Power System Analysis, 3rd Edition, Hadi Saadat, PSA Publication.

4) Modern Power System Analysis, 4th Edition, D P Kothari and I J Nagrath, Tata McGraw Hill Education.

5) Power Systems Analysis, T.K. Nagsarkar and M.S. Sukhija, Oxford University Press.

6) Electric Power Engineering Handbook, Leonard L. Grigsby, CRC Press.

7) Modern Power System Analysis, 2nd Edition, Toran Gonen, CRC Press.

8) Electric Power Principles: Sources, Conversion, Distribution and Use, 1st Edition, James L. Kirtle, Wiley.

9) Power System Analysis and Design, 6th Edition, J. Duncan Glover, Thomas Overbye and Mulukutla S. Sarma, Cengage Learning.

10) Power Systems Analysis, 2nd Edition, Arthur R. Bergen and Vijay Vittal, Pearson.

14.47 Digital Signal Processing Laboratory

14.47.1 Introduction of the Course

Course Code and Title: 0714-EEE-3204: Digital Signal Processing Laboratory

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week

Rationale of the Course: The Digital Signal Processing (DSP) laboratory course focuses on the practical applications and analysis of signals to extract and enhance desired information, aligning with the concepts covered in the theory course 0714-EEE-3203: Digital Signal Processing. The primary goal of this lab is to equip students with hands-on experience through simulation using industry-standard software like MATLAB and by performing experiments on hardware platforms and general-purpose DSP development kits. The lab experiments cover core DSP concepts such as A/D and D/A conversions, convolution, correlation, signals and systems analysis using DFT, FFT, and z-transform, along with the design and implementation of FIR and IIR digital filters.

Prerequisites (if any): 0714-EEE-2109: Signals and Systems.

14.47.2 Course Objectives

The Students are expected to:

1) Gain hands-on experience with essential DSP concepts, including signal representation, signal transformation and filtering techniques.

2) Develop proficiency in MATLAB for simulating, analyzing, and visualizing digital signal processing systems.

3) Understand the analog-to-digital conversion process and apply techniques for accurate signal reconstruction.

4) Explore the applications of convolution sum, auto-correlation, and cross-correlation in digital signal processing and communication systems.

5) Acquire practical experience in analyzing signals and systems using the Discrete Fourier Transform (DFT), its efficient implementation with FFT algorithms, and z-transform techniques.

6) Design, implement, and evaluate FIR and IIR digital filters to meet specific technical requirements in communication and control system applications.

14.47.3 Course Content

Experiments in relevance with the 0714-EEE-3203: 3203 Digital Signal Processing course.

Projects related to EEE 3203 Digital Signal Processing course contents to achieve specific program outcomes.

14.47.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate the ability to implement and manipulate discrete-time signals and systems using MATLAB.	PO1, PO2, PO5	C3	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva
CO2	Analyze the response of LTI systems in both time and frequency domains for different types of input signals.	PO2, PO4	C4	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva
CO3	Evaluate and apply correlation techniques for signal	PO1, PO2, PO5	C6	Lectures, Simulation, Experiment	Project report, Presentation, Viva

	processing applications.				
CO4	Design and implement digital FIR and IIR filters to meet specific requirements.	PO3, PO5	C5	Lectures, Simulation, Experiment	Lab reports, Hardware demonstration, Lab test
CO5	Collaborate effectively in teams to propose, execute, and present DSP projects with practical significance.	PO9, PO10, PO12	A4	---	Project report, Presentation

14.47.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓		✓				✓				✓		✓	✓		✓		

14.47.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments and projects; Formation of groups/teams for design projects and laboratory works	---
2	Introduction	Introductory MATLAB Tutorial	---
3	Experiment 01	Implementation of elementary Discrete-Time (D-T) signals and operations on D-T signals.	CO1
4	Experiment 02	Analog-to-Digital conversion and reconstruction of analog signal.	CO1
5	Experiment 03	Response of linear time-invariant (LTI) systems to arbitrary input signal in time and frequency domains.	CO2
6	Experiment 04	Applications of auto-correlation and cross-correlation in digital signal processing.	CO3
7	Experiment 05	Implementation of sinusoids and Fourier analysis of continuous-time periodic signals.	CO2

8	Experiment 06	Analysis of difference equation of a system (filter) in z-domain.	CO3
9	Experiment 07	Design and analysis of Null Filter for biomedical applications.	CO4
10	Experiment 08	Design of FIR filters using windowing method.	CO4
	Experiment 09	Design and Performance Analysis of digital IIR filters	
11	Project Proposal Presentation	Distribution of projects among different teams; Describe specific technical requirements to be attained during the project	CO5
12	Experiment	Review of Experiment 01 to 09	---
13	Project demonstration and presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence that specific technical requirements have been attained by the project	CO5
14	Examination	Final evaluation on Experiment 01 to 09	---

14.47.7 Assessment Pattern/ Strategy

The assessment of this course will be based on a combination of assignments, lab reports, project work, presentations, and examinations to ensure a comprehensive evaluation of students' practical skills and theoretical understanding. Students will be assessed on their ability to implement and analyze DSP concepts using MATLAB and hardware platforms, as well as their proficiency in signal processing techniques, system analysis, and filter design.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.47.8 Text Books and Reference Books

1) Digital Signal Processing - Principles, Algorithms and Applications, 3rd Edition, John G. Proakis and Dimitris G. Manolakis, Prentice-Hall International, Inc.

2) Digital Signal Processing Using Matlab: A Problem Solving Companion, 4Th Edition, 2017, Vinay K. Ingle and John G. Proakis, Cengage Learning

3) Digital Signal Processing Using MATLAB, 2nd Edition, 2007, André Quinquis, John Wiley & Sons, Inc.

4) Digital Signal Processing Using MATLAB for Students and Researchers, 1st Edition, 2011, John W. Leis, John Wiley & Sons, Inc.

14.48 Electrical Services Design and Drafting Laboratory

14.48.1 Introduction of the Course

Course Code and Title: 0713-EEE-3214: Electrical Services Design and Drafting Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: The lab course allows students to apply theoretical knowledge gained from design courses into practical scenarios. It provides an opportunity to design electrical systems and components for real-world applications, such as residential, commercial, or industrial buildings. The course focuses on developing skills in creating detailed engineering drawings, schematics, diagrams, and specifications. This is crucial for communicating design intent effectively to stakeholders, including clients, contractors, and regulatory authorities.

Prerequisites (if any): 0732-CIV-1112: Computer Aided Engineering Drawing.

14.48.2 Course Objectives

The students are expected to

1) Acquaint professional rules and regulations of wiring and electrical protection system for residential and commercial building, industry etc.

2) Enable students to apply fundamental principles of electrical engineering to design electrical systems for residential, commercial, and industrial applications.

3) Enable students to create comprehensive engineering documentation including drawings, schematics, layouts, and specifications that effectively communicate design intent.

4) Develop skills at designing electrical wiring system with security system, illumination, lightning protection system etc.

14.48.3 Course Content

Electrical Design Principles: Overview of electrical systems and their components, Basic principles of electrical design, Importance of standards, codes, and regulations in electrical design.

Electrical Load Calculation: Methods for calculating electrical loads in residential, commercial, and industrial settings, Voltage drop calculations and mitigation strategies, Power factor correction considerations.

Electrical System Layout and Design: Design considerations for electrical distribution systems, Layout and sizing of cables, wires, conduits, and busbars, Equipment selection and placement (e.g., transformers, switchgear, distribution panels).

Lighting Design, Home Security and Safety Design and Control Systems: Principles of lighting design (ambient, task, and accent lighting), Selection and placement of lighting fixtures, Introduction to lighting control systems (e.g., manual, automatic, programmable), Fire Alarm, CCTV, Burglar Alarm, Smoke Detector and Sprinklers, type of circuit breakers, earthing requirements, various earthing methods.

14.48.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Explain the fundamental concept of civil drawing for electrical designing purpose	PO1	C1	Lectures, Group discussion	Viva, Quiz, Project
CO2	Apply different electrical wiring techniques in practical building design	PO1	C3	Lectures, Group discussion, Exercise	Lab reports, Viva, Quiz,
CO3	Evaluate electrical safety and earthing protection requirements	PO2, PO6	C4	Group discussion, Exercise	Lab reports, Viva, Quiz,
CO4	Design the security systems, intercommunication systems and LAN	PO3	C6	Group Work, Exercise	Project Report

14.48.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓				✓		✓							✓	✓			

14.48.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction to electrical services design: definitions and meaning –services, design, installation, lighting, illumination; power supply system; power distribution system and electrical wiring.	CO1
2	Discussion and Demonstration	Familiarization with building regulations, codes and standards (BNBC, NFPA etc.), protective devices: relays, fuse, circuit breakers, grounding & hazards, earthing.	CO1
3	Discussion and Demonstration	Design of Home Security and Safety: Fire Alarm, CCTV, burglar Alarm, smoke detector and sprinklers.	CO3

4	Experiment 01	Layout of civil drawing of a multi-storied building (residential, commercial, industrial etc.).	CO2
5	Experiment 02	Fittings and Fixture Layout of a multi-storied building (residential, commercial, industrial etc.).	CO2
6	Experiment 03	Distribution board and Switch Board connection diagram of a multi-storied building (residential, commercial, industrial etc.).	CO2
7	Experiment 04	Load calculation and wire selection of a multi-storied building.	CO2
8	Experiment 05	Design and layout of a substation (Single Line Diagram).	CO2
9	Experiment 06	Earthing requirements, various earthing methods, earthing and lightning protection system design.	CO4
10	Discussion and Exercise	Detailed calculation of each type of circuit breakers including their normal current rating, short circuit current rating and type. Detailed estimation of overall design cost.	CO4
11-12	Discussion	Review class	-
13	Lab Quiz	A Quiz will be held based on all experiments.	-
14	Lab Viva	A table viva will be held based on all experiments.	-

14.48.7 Assessment Pattern/ Strategy

Assessment will be based on following indicators.

Class Attendance: Attendance of every lab session will be recorded.

Lab Report: After completing each laboratory experiment, each student has to write a laboratory report on that experiment. Students will have one week to submit the laboratory report. Oral test will be taken based on submitted report.

Project Report: Students will have to make a mini-project based on the laboratory course. Project topic will be allocated before mid-semester break and have to submit before the quiz test.

Quiz: After the completion of all laboratory experiment, a quiz test will be taken.

Lab Viva: After the quiz test, an oral exam will be taken based on the course.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.48.8 Text Books and Reference Books

1) Design of Electrical Services for Buildings, 4th Edition, Barrie Rigby.

2) Handbook of Electrical Design Details, 2nd Edition, Neil Sclater, John E. Traister.

14.49 Power Electronics and Industrial Automation

14.49.1 Introduction of the Course

Course Code and Title: 0714-EEE-4101: Power Electronics and Industrial Automation.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The course is designed to provide a comprehensive understanding of the fundamental principles of power semiconductor devices and their applications. The course aims to equip students with the knowledge and skills necessary to analyze, design, and implement power electronic converters for efficient conversion and control of electrical energy. Furthermore, the curriculum recognizes the practical importance of power electronics in key applications, such as motor drives and industrial automated controllers. This course will help students develop a strong foundation for advanced power electronics.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0714-EEE-2101: Analog Electronics I.

14.49.2 Course Objectives

The students are expected to

1) Acquire a comprehensive understanding of switching principles and the operational characteristics of semiconductor devices.

2) Analyze the working mechanism of converters and deduce the output voltage and current responses from diverse circuit configurations.

3) Explore the performance parameters and principles of operation of converters and inverters, understanding their roles in power electronic systems.

4) Develop a deep understanding of industrial motor drives, covering the basic characteristics, operating modes, single-phase and three-phase drives, and motor control strategies.

5) Master the principles of Programmable Logic Controllers (PLC) and Human-Machine Interface (HMI) systems needed for efficient and effective industrial automation.

14.49.3 Course Content

Introduction: Types of Power Electronic Circuits, Determining the Root-Mean- Square Values of Waveforms, Characteristics and Specifications of Switches, Power Semiconductor Devices, Device Choices, Power Diodes and Switches.

RLC Circuits: Diode Characteristics, Reverse Recovery Characteristics, Diode Switched RC Load, Diode Switched RL Load, Diode Switched LC Load, Freewheeling Diodes with Switched RL Load, Recovery of Trapped Energy with a Diode.

Diode Rectifiers: Performance Parameters, Single-Phase Full-Wave Rectifiers, Single-Phase Full-Wave Rectifier with a Highly Inductive Load, Three-Phase Bridge Rectifiers.

DC–DC Converters: Performance Parameters of DC–DC Converters, Principle of Step-Down Operation, Principle of Step-Up Operation, Converter Classification, Switching-Mode Regulators, Buck Regulators, Boost Regulators, Buck–Boost Regulators.

DC–AC Converters: Performance Parameters, Principle of Operation, Single-Phase Bridge Inverters, Three-Phase Inverters.

Thyristors: Two-Transistor Model of Thyristor, Thyristor Turn-On, Thyristor Turn-Off, Thyristor Types, di/dt Protection, dv/dt Protection, Thyristor Firing Circuits.

Industrial Motor Drives: Basic Characteristics of DC Motors, Operating Modes, Single-Phase Drives, Three-Phase Drives, DC–DC Converter Drives, Stepper Motor Control, Microcomputer Control of DC Drives.

PLC and HMI for Industrial Automation: Controllers, Hardware, Internal Architecture, Programming, Testing and Debugging, HMI Development and Programming.

14.49.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Gain a comprehensive understanding of the operational characteristics and switching principles of semiconductor devices	PO1	C1, C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Design and analyze power conversion circuits and deduce output voltage and current responses through a comprehensive understanding of circuit dynamics.	PO2, PO3	C3, C4, ~~C6~~	Lectures Discussions Exercise Handouts	Assignment Final Exam
CO3	Investigate the performance parameters and operational principles of converters and evaluate suitable converters for real-world applications	PO4, PO7	C3, C4	Lectures Discussions Exercise Handouts	Incourse Final Exam

CO4	Develop a profound understanding of the significance and architecture of industrial automation and realize the role of controllers in orchestrating efficient and effective automation systems	PO1, PO11	C1, C2	Lectures Discussions Handouts	Presentation Final Exam

14.49.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓			✓	✓		✓	✓						✓	✓	✓		

14.49.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Power Electronics and Power Semiconductor Devices, Types of Power Electronic Circuits, Determining the Root-Mean- Square Values of Waveforms, Characteristics and Specifications of Switches.	---
2	3-4	Power Diodes, Diode Characteristics, Reverse Recovery Characteristics, Diode in Switched Circuits.	CO1
3	5-6	Freewheeling Diodes with Switched RL Load, Recovery of Trapped Energy with a Diode, Introduction to Rectifiers, Single-Phase Full-Wave Rectifiers with RC and RL loads.	CO1, CO2
4	7-8	Single-Phase Full-Wave Rectifier with a Highly Inductive Load, Performance Parameters, Harmonics and Input Power Factor, Multiphase Star Rectifiers (Basics), Three-Phase Bridge Rectifiers.	CO2
5	9-10	Introduction to Thyristors, SCR Characteristics, Two-Transistor Model of Thyristor of SCR, Thyristor Turn-On, Thyristor Turn-Off.	CO1
6	11-12	Thyristor Types, Thyristor Protection Circuits, Introduction to Controlled Rectifiers, Single-Phase Full Controlled Rectifier with an RL Load, Performance Parameters.	CO1, CO2

7	13-14	Modes of Operation of Full Converters, Single Phase Dual Converters with RL Load, Power MOSFETs, Steady State and Switching Characteristics of Power MOSFETs.	CO1, CO2
8	15-16	Operation of Insulated Gate Transistors, Comparison of Transistors, Introduction to Choppers, Switching-Mode Regulators, Principle of Step-Down Operation, Generation of Duty Cycle, Buck Regulators.	CO1, CO2
9	17-18	Principle of Step-Up Operation, Boost Regulators, Buck-Boost Converter, Introduction to Inverters, Single Phase Half Bridge Inverter - RL Load, Performance Parameters and Harmonics.	CO2, CO3
10	19-20	Three-Phase Inverters – 180 and 120 Degree Conduction Modes, Introduction to AC-AC converters, Single-Phase Full-Wave Controllers with RC and RL Loads, Performance Parameters.	CO2, CO3
11	21-22	Single Phase Cycloconverters, Review of DC Motors, Basic Characteristics of Separately Excited DC Motors, Operating Modes, Single-Phase Drives.	CO2, CO3 CO4
12	23-24	Single Phase Semiconverter Drives, Single Phase Full Converter Drives, Dual Converter Drives, DC-DC Converter Drives, Stepper Motor Control, Microcomputer Control of DC Drives.	CO2, CO3 CO4
13	25-26	Introduction to Industrial Automation, Controllers, Hardware, Internal Architecture, Programming.	CO4
14	27-28	Testing and Debugging, HMI Development and Programming.	CO4

14.49.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Students will be assigned home tasks every other week. All the homeworks should be compiled and submitted in the form of a single assignment during the last week of the semester.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%

Total	100%

14.49.8 Text Books and Reference Books

1) Power Electronics, 1st Edition, Daniel W Hart, McGraw-Hill Education.

2) Power Electronics: Circuits, Devices & Applications, 4th Edition, Muhammad H. Rashid, Pearson.

3) Power Semiconductor Circuits, S. B. Dewan and A. Straughen, Wiley.

4) Power Electronics: Converters, Applications, and Design, 3rd Edition, Ned Mohan, Tore M. Undeland and William P. Robbins, Wiley.

5) Fundamentals of Power Electronics, 2nd Edition, Robert W. Erickson and Dragan Maksimovic, Springer.

6) Pulse-Width Modulated DC-DC Power Converters, 1st Edition, Marian K. Kazimierczuk, Wiley.

14.50 Professional Ethics

14.50.1 Introduction of the Course

Course Code and Title: 0223-GED-4103: Professional Ethics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Professional Ethics course is essential for the students of engineering disciplines. Engineering practice often involves making decisions that have significant impacts on public safety, health, the environment, and society as a whole. This course is designed to prepare engineers with the frameworks and principles necessary to navigate complex ethical dilemmas. Engineers must be able to assess situations where the right course of action is not immediately obvious. Ethical theories, such as utilitarianism, deontology, and virtue ethics, offer tools to evaluate potential outcomes and guide engineers toward responsible and morally sound decisions.

Prerequisites (if any): No prerequisite.

14.50.2 Course Objectives

The students are expected

1) To understand about their professional characteristics, concept and boundary line.

2) To develop their idea about philosophy of different branches specifically in the branch of ethics.

3) To understand different sources of ethics that prepares engineers with the frameworks and principles necessary to navigate complex ethical dilemmas.

4) To understand their obligation in engineering practice. It is often involved making decisions that have significant impacts on public safety, health, the environment, and finance and business.

5) To understand different laws concerning engineering practice.

14.50.3 Course Content

Introduction to Profession: Definition of a Profession, Characteristics of a Profession, Concept of Professional Engineer, Boundary Line Profession and Semi Profession.

Introduction to Philosophy: Different Branches of Philosophy, Philosophical Methods: Epistemology, Ontology, Axiology, Inductive and Deductive Reasoning, Definition and Scope of Ethics, Ethics as a Branch of Philosophy.

Different Sources of Ethics: Different Branches of Ethics: Meta Ethics, Normative Ethics, Applied Ethics, Different Framework of Ethics: Deontological, Teleological and Virtue Ethics, Moral Agent, Ethical Community, Moral Imagination and Ethical Compass, Different Methods of Ethical Decision Making, Moral Psychology, Ethical Relativism, Factors of Limited Ethicality, Evolution of Ethics as a Discipline, History and Development of Engineering Ethics, History of Engineering Education in Pre and Post Industrial Revolution and Development of Engineering Ethics, Development of Engineering Professional Bodies and Enforcement of Code of Conduct, Characteristics of a Professional Code.

Obligation of an Engineer: Prohibitive, Preventive and Aspirational Ethics, Micro, Meso and Macro Ethics, Avoidance of Conflict of Interest, Whistleblowing, Fiduciary Duty, Improvement of the Quality of Engineering Profession, Environmental Ethics, Information and Computer Ethics, Financial and Business Ethics.

Law and Ethics: Different Laws Concerning Engineering Practice, Breach of Trust, Inevitable Disclosure Doctrine, and System of Justice Delivery in Bangladesh.

14.50.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the professional characteristics, concept and the boundary line and also the philosophy of different branches specifically in the branch of ethics.	PO1	C1, C2	Lectures Handouts	Incourse Final Exam
CO2	Analyze different sources of ethics and apply it to different engineering practices.	PO1, P10	C2, C4	Lectures Handouts Discussions	Incourse Final Exam
CO3	Apply the ethical obligations in engineering practice that have	PO9, P10	C3, A1	Lectures Handouts Discussions	Assignment Final Exam

	significant impacts on public safety, health, environment, and finance and business.				
CO4	Understand different rules and regulations of professional ethics.	PO1	C1, C2	Lectures Handouts Discussions	Assignment Final Exam

14.50.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
						✓		✓	✓						✓				

14.50.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-3	Introduction to Profession: Definition of a Profession, Characteristics of a Profession, Concept of Professional Engineer, Boundary Line Profession and Semi Profession.	CO1
2-4	4-8	Introduction to Philosophy: Different Branches of Philosophy, Philosophical Methods: Epistemology, Ontology, Axiology, Inductive and Deductive Reasoning, Definition and Scope of Ethics, Ethics as a Branch of Philosophy.	CO1
5-6	9-12	Different Sources of Ethics: Different Branches of Ethics: Meta Ethics, Normative Ethics, Applied Ethics, Different Framework of Ethics: Deontological, Teleological and Virtue Ethics, Moral Agent, Ethical Community, Moral Imagination and Ethical Compass, Different Methods of Ethical Decision Making, Moral Psychology, Ethical Relativism, Factors of Limited Ethicality	CO2
7-8	13-16	Evolution of Ethics as a Discipline, History and Development of Engineering Ethics, History of Engineering Education in Pre and Post Industrial Revolution and Development of Engineering Ethics, Development of Engineering Professional Bodies and Enforcement of Code of Conduct, Characteristics of a Professional Code.	CO2
9-10	17-20	Obligation of an Engineer: Prohibitive, Preventive and Aspirational Ethics, Micro, Meso and Macro Ethics, Avoidance of Conflict of Interest, Whistleblowing, Fiduciary	CO3

		Duty.	
11-12	21-24	Improvement of the Quality of Engineering Profession, Environmental Ethics, Information and Computer Ethics, Financial and Business Ethics.	CO3
13-14	25-28	Law and Ethics: Different Laws Concerning Engineering Practice, Breach of Trust, Inevitable Disclosure Doctrine, and System of Justice Delivery in Bangladesh.	CO4

14.50.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.50.8 Text Books and Reference Books

1) Engineering Ethics, 4th Edition, Charles B Fleddermann, Pearson.

2) Edmund G Seebauer and Robert L Barry, “Fundamentals of Ethics for Scientists and Engineers”, Oxford University Press, 2001.

3) David Ermann and Michele S Shauf, “Computers, Ethics and Society”, Oxford University Press, (2003)

4) John R Boatright, “Ethics and the Conduct of Business”, Pearson Education, 2003.

5) Prof. (Col) P S Bajaj and Dr. Raj Agrawal, “Business Ethics – An Indian Perspective”, Biztantra, New Delhi, 2004.

14.51 Power Electronics and Industrial Automation Laboratory

14.51.1 Introduction of the Course

Course Code and Title: 0714-EEE-4102: Power Electronics and Industrial Automation Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: This course aims to provide students with practical, hands-on experience in applying concepts related to power electronics and industrial automation. It provides students with a platform to gain practical insights into the design, construction, and performance evaluation of power electronic circuits in terms of energy conversion and regulation. This practical exposure also equips them with the skills necessary for industrial automation, preparing them for the challenges of modern engineering practices.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0714-EEE-2101: Analog Electronics I.

14.51.2 Course Objectives

The students are expected to

1) Reinforce theoretical insights gained in Power Electronics and Industrial Automation course by applying it to practical scenarios and verify the convergence of between theoretical knowledge and real-world applications.

2) Have a hands-on experience in designing, constructing, and evaluating the efficiency of power electronic converters.

3) Develop skills in testing and troubleshooting power electronic circuits to understand the impact of various parameters and conditions on system performance.

14.51.3 Course Content

Experiments in relevance with the 0714-EEE-4101 Power Electronics and Industrial Automation course.

Projects related to 0714-EEE-4101 Power Electronics and Industrial Automation course contents to achieve specific program outcomes.

14.51.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate hands-on experience in designing and implementing power electronic circuits for specific applications	PO3	C3, C4, P3	Lectures, Experiment, Group Work	Lab Reports, Lab Test: Experiment Demonstra-tion and Viva
CO2	Analyze the behavior and responses of power converters and	PO2, PO3	C3, C4, P3	Lectures, Experiment, Group Work	Lab Reports, Lab Test: Experiment Demonstra-

	evaluate their efficiency.				tion and Viva
CO3	Acquire the ability to design power electronic circuits which are useful in day-to-day life.	PO3, PO11	C3, A2	Lectures, Experiment, Project	Lab Reports, Lab Test: Experiment Demonstra-tion and Viva
CO4	Demonstrate effective communication of project outcomes	PO10	C6, A2	---	Reports, Presentatio n

14.51.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
	✓			✓	✓			✓	✓	✓				✓	✓	✓	✓		✓

14.51.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Overview of power electronics, power semiconductor devices and the experiments, Formation of groups for laboratory works.	---
2-3	Experiment 1	To study the output and the transfer characteristics of power MOSFET.	CO1
4-5	Experiment 2	To construct switching circuits: Unidirectional and Bi-directional.	CO1, CO3
6	Experiment 3	To design and develop a phase control circuit and use it as light dimmer.	CO1, CO3
7	Experiment 4	To design and develop a square wave inverter and study its performance.	CO2
8-9	Experiment 5	To design and study the performance of a buck-boost converter.	CO2
10	Project Proposal Presentation	Distribution of projects among different teams; Describe specific technical requirements to be attained during the project	---
11	Review and Practice	Practice the experiments, Preparation for the final assessment.	---

12	Project presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence that specific technical requirements have been attained by the project	CO4
13-14	Final Evaluation	Demonstrate Experiments, Take the Viva-Voce Exam	---

14.51.7 Assessment Pattern/ Strategy

Students will be assessed based on their successful completion of all experiments, their ability to comprehend circuit operations and interpret output data. Evaluation will also focus on individual's proficiency in performing experiments. Additionally, students will be continuously assessed every week based on their responsiveness to instructor's questions related to the experiments.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.51.8 Text Books and Reference Books

1) Power Electronics, 1st Edition, Daniel W Hart, McGraw-Hill Education.

2) Power Electronics: Circuits, Devices & Applications, 4th Edition, Muhammad H. Rashid, Pearson.

14.52 Device Fabrication Techniques

14.52.1 Introduction of the Course

Course Code and Title: 0714-EEE-4131: Device Fabrication Techniques.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The course is designed to provide a comprehensive and systematic discussion on different processing steps involved in semiconductor device fabrication techniques, from wafer to integrated chip (IC) production. The challenges that prevail in IC manufacturing industry are highlighted and how to overcome them are discussed in details. The state-of-the-art manufacturing processes are covered. This course aims to equip students with necessary knowledge and skill to develop a strong foundation necessary to cope with upcoming advancement in this field in near future.

Prerequisites (if any): 0533-PHY-1103: Electricity and Magnetism, 0531-CHE-1207: Chemistry, 0714-EEE-2105: Solid State Physics.

14.52.2 Course Objectives

The students are expected to

1) Acquire knowledge about the different processing steps involved in semiconductor device manufacturing from wafer to IC chip.

2) Understand the physics behind each device fabrication techniques. Explore their limitations and possibilities to overcome the existing challenges.

3) Study and analyze the state-of-the-art fabrication techniques exists in today's world and understand their impact on betterment of human civilization.

14.52.3 Course Content

Crystal Structure: Silicon as Indirect Band Gap Material, Crystal Structure and its Property, GaN, GaAs as Direct Band Gap Materials, Crystal Structure and their Properties, Miller-Bravis Indices, Weber Symbol, Zone Axis Symbol, Reciprocal Lattice, Hexagonal and Cubic Closest Packings, Body Centered Cubic Packing, Voids in Closest Packings and Body Centered Cubic Packing.

Crystal Growth Technology: Phase Diagram and Solid Solubility, Metallurgical and Electronic Grade of Growth, Purification of Grown Crystals, Czhorkralski Method, Float-Zone Method, Wafer Preparation and Specifications, Shaping of Wafers, Solution Growth, Sol-Gel Method.

Epitaxial Growth: Epitaxy, Gas Kinetics, Vapor Phase Epitaxy (VPE), Molecular Beam Epitaxy (MBE), Metal Organic Chemical Vapor Deposition (MOCVD), Organo Metallic Vapor Phase Epitaxy, HVPE, Plasma-Assisted CVD, Chemical Beam Epitaxy, Atomic Layer Deposition, Different Growth Processes of Si Epitaxy: Their Advantages and Disadvantages, Doping During Epitaxy, Auto- Doping and its Effect- Junction Shift, Pattern Shift and Distortion, In-situ Cleaning for Si Epitaxy and its Necessities, Defects in Epitaxial Layer: Stacking Fault, Misfit and Threading Dislocation and their Origin, Dislocation Types, Technique to Identify Types of Dislocation.

Deposition of Dielectric Layers: Thermal Oxidation: Deal and Grove Model, Wet and Dry Oxidation Process, Silicon Nitride Growth.

Lithography: Mask for Lithography, Photo-Resist Materials, Positive and Negative Photolithography, E-Beam and X-Ray Lithography, Extreme UV (EUV) Lithography, Pros and Cons of Different Lithography Techniques.

Etching: Etch Parameters, Wet Etching, Dry Etching: Plasma Etching, Ion Beam Etching, Sputtering Etching and Reactive Ion Etching, Lift-Off Techniques, Stripping of Resist Materials, Self-Aligned Double Patterning (SADP) and Self- Aligned Quadruple Patterning (SAQP).

Diffusion and Ion Implantation: Theory of Diffusion, Infinite and Finite Diffusion Processes, Ion Implantation Processes, Doping Profile for Diffusion and Ion Implantation Systems.

Metallization: Types of Metals, Metal Deposition Systems: Evaporation, Sputtering, Metal CVD, Copper Electroplating.

Gas Control in Process Chambers: Vacuum Ranges, Vacuum Pumps: Roughing Pump, High Vacuum Pump, Mass Flow Controller, Residual Gas Analyzer, Plasma: Glow Discharge, Radicals.

Clean Room: Contamination Control, Impurities Control, Classification of Clean Room, Design Strategy and Construction of Clean Room.

Assembly and Packaging: Backgrind by Chemical Mechanical Polishing, Die Separation: Scribing, Cleaning and Inspection, Die Attach, Wire-Bonding, IC Packaging.

14.52.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Acquire knowledge about device manufacturing processes	PO1, PO2	C1, C2	Lectures Discussions Exercise Handouts	Assignment In-course Final Exam
CO2	Understand the physics involved in the device fabrication process and explore their limitations and possibilities to overcome the challenges	PO1, PO2, PO3	C1, C4	Lectures Discussions Exercise Handouts	Assignment In-course Final Exam
CO3	Study and analyze the state-of-the-art fabrication techniques exists in today's world and understand their impact on betterment of human civilization	PO12	C1, A4, P3, P6	Lectures Discussions Exercise Handouts	Assignment In-course Final Exam

14.52.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓						✓			✓					✓	

14.52.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-3	1-6	Crystal Structure and Crystal growth technology	CO1, CO2

4-5	7-10	Deposition of Dielectric Layers	CO1, CO2
6-7	11-13	Lithography and Etching processes	CO1, CO2
7-9	14-17	Diffusion and Ion Implantation	CO1, CO2
9-11	18-22	Different Epitaxial Growth processes	CO2, CO3
12	23-24	Metallization and Gas control in process chamber	CO1, CO2
13-14	25-28	Clean room, Assembly and Packaging	CO3

14.52.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Students will be assigned home tasks or assignments on regular basis. The assignment should be submitted within one week from the assign date.

3) In-course: There will be a minimum 1 in-course exam; if 2 or more in-course exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.52.8 Text Books and Reference Books

1) The Basics of Crystallography and Diffraction, Christopher Hammond, 2nd Edition, Oxford University Press.

2) Electronic Processes in Materials, Leonid V. Azaroff and James J. Brophy, McGraw-Hill Book Company.

3) Semiconductor Manufacturing Technology, 1st Edition, Michael Quirk and Julian Serda, Prentice-Hall.

4) VLSI Fabrication Principles Silicon and Gallium Arsenide, 2nd Edition, Sorob K. Ghandi; John Wiley and Sons. Inc.

5) Lecture Series on VLSI Design by Dr. Nandita Dasgupta, Department of Electrical Engineering, IIT Madras.

6) Silicon Processing for the VLSI Era, Vol I, II, and III, S. Wolf and R. N. Tauber, Lattice Press.

7) Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6th Edition, Peter Van Zant, McGraw-Hill Education.

8) Fabrication Engineering at the Micro- and Nanoscale, 4th Edition, Stephen A. Campbell, Oxford University Press.

9) The Science and Engineering of Microelectronic Fabrication, 2nd Edition, Stephen A. Campbell, Oxford University Press.

14.53 VLSI Circuit Design

14.53.1 Introduction of the Course

Course Code and Title: 0714-EEE-4133: VLSI Circuit Design.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is fundamental to understanding the principles and practices that underpin modern electronic devices and systems. As technology advances, the demand for more efficient, faster, and smaller electronic components increases, necessitating a deep comprehension of VLSI design and its applications. This course provides a comprehensive overview of CMOS circuits, MOS transistor theory, processing technology, and subsystem design, equipping students with the necessary knowledge and skills to design and implement complex integrated circuits.

Prerequisites (if any): 0714-EEE-2103: Digital Electronics, 0714-EEE-3109: Electronic Devices.

14.53.2 Course Objectives

The students are expected to

1) Understand and analyze the VLSI design flow and MOS transistor theory.

2) Learn and apply CMOS processing technology and layout design rules.

3) Master circuit characterization, performance, and design CMOS logic.

4) Design and implement VLSI subsystems and advanced circuit components.

14.53.3 Course Content

CMOS Circuits: VLSI Design Flow, MOS Transistor, CMOS Logic, Circuit Representation, nMOS and pMOS Transistors, MOS Transistor Design, CMOS Inverter, NAND, NOR, Complex CMOS Gates, XOR, Transmission Gates (TGs).

MOS Transistor Theory: MOS Transistor Theory, Enhancement pMOS and nMOS devices, MOS Device Design Equations, MOSFET RC Model and CMOS Capacitances, DC Characteristics and Transient Analysis of a CMOS Inverter.

CMOS Processing Technology: CMOS Process Flow, CMOS Fabrication, CMOS Layers and Gate Layout, Complex Gate Layout, Stick Diagrams, Layout Design Rules, Latchup.

Circuit Characterization and Performance Evaluation: Delay Estimation, Logical Effort, Inverter Speed and Power Dissipation, Interconnects, Transistor Sizing.

CMOS Logic and Design: Physical Design of Logic Gates, CMOS Logic Structures, Layout Techniques, Hierarchical Design, Differential and Dynamic Logic, I/O Structures, Clock, Design Methods, Design Strategies, Design Options- Gate Arrays, Gate Design/Analysis, Multi-Cell Layout, Inter-Cell Routing, Submicron Design, Advanced Design Tools- Capture and Verification.

Subsystem Design: Adders, Comparators, Multipliers, Latches and Flip Flops, Tri-States, C2MOS, Multiplexers, Decoders, Shifters, Memory Basics, SRAM Cells and Arrays, Programmable Logic Arrays (PLAs), Data Path and Control Unit, Register File, Arithmetic Logic Unit (ALU).

14.53.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a comprehensive understanding of the VLSI design flow and MOS transistor operation	PO1, PO2	C1, C2	Lectures Discussions Exercise Handouts	Assignment Incourse Final Exam
CO2	Apply knowledge of CMOS process flow, fabrication methods, layer structures, and layout design rules to create efficient and reliable CMOS circuits	PO3, PO5	C3	Lectures Discussions Exercise Handouts	Assignment Incourse Final Exam
CO3	Evaluate and optimize the performance of CMOS circuits to enhance the speed and efficiency of CMOS circuits	PO4, PO8	C4	Lectures Discussions Exercise Handouts	Assignment Incourse Final Exam
CO4	Develop and implement VLSI subsystems demonstrating proficiency in VLSI circuit design	PO1, PO3, PO5	C1, C3	Lectures Discussions Exercise Handouts	Assignment Incourse Final Exam

14.53.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓			✓	✓	✓		✓	✓				✓	✓	✓			✓		✓

14.53.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1	Overview of VLSI and the current status of the VLSI industry in Bangladesh	CO1
1-2	2-4	MOS transistor theory	CO1
3-4	5-7	CMOS fabrication	CO2
4-5	8-10	Logic design with MOSFETs	CO2
6	11-12	Layout design rules	CO2
7	13	MOSFET scaling	CO2
7-8	14-16	DC switching and power dissipation in the device	CO3
9	17-18	Logical effort, RC delay model	CO3
10	19-20	Interconnects	CO4
11	21-22	Sequential circuits- Latches and Flip, flops	CO4
12	23-24	Memory Basics and categories, SRAM Cells and Arrays	CO4
13	25-26	Arithmetic Circuits	CO4
14	27-28	Shifter	CO4

14.53.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum of 1 Assignment and/or presentation; if 2 or more assignments or presentations are taken then their average will be considered in the final evaluation.

3) Incourse: There will be a minimum of 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in the final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.53.8 Text Books and Reference Books

1) CMOS VLSI Design, 3rd Edition, Neil Weste and David Harris, Addison Wesley.

2) John P. Uyemura, "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Inc.

3) Digital Integrated Circuit Design, K. Martin, Oxford University Press.

4) CMOS Circuit Design, Layout, and Simulation, R. Jacob Baker, Harry W. Li and David E. Boyce, Wiley-IEEE Press.

14.54 VLSI Design Laboratory

14.54.1 Introduction of the Course

Course Code and Title: 0714-EEE-4134: VLSI Design Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: Students will learn to design and measure the performance of simple circuits using Cadence Virtuoso software. By accomplishing the final project students are expected to acquire the skill of designing an advanced circuit including hardware descriptive language, writing the test bench, synthesis, and physical design.

Prerequisites (if any): 0714-EEE-2103: Digital Electronics, 0714-EEE-3109: Electronic Devices.

14.54.2 Course Objectives

The students are expected to

1) To develop familiarity and learn basics about Cadence Virtuoso software, PDK, and Custom IC Design flow.

2) To layout design, and test digital circuits using the Cadence Virtuoso software.

3) Design a complete advanced circuit including hardware descriptive language (Verilog code), writing the test bench, synthesis, and physical design (PnR).

14.54.3 Course Content

Experiments in relevance with the 0714-EEE-4133: VLSI Circuit Design course.

Projects related to 0714-EEE-4133: VLSI Circuit Design course contents to achieve specific program outcomes.

14.54.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Construct schematic and layout of integrated circuits (ICs) made of MOSFETs using	PO1, PO3, PO5	C1, C3, C5, C6	Lectures, Simulation, Experiment	Lab reports, Lab test, Viva, Project

	Cadence Virtuoso tool				
CO2	Measure the performance of a designed IC based on the effects of different parameters	PO1, PO3, PO5	C1, C3, C5, C6	Lectures, Simulation, Experiment	Lab reports, Lab test, Viva, Project
CO3	Demonstrate team-based project based on HDL code for a given problem in digital circuit design, then write the test bench, do synthesis, and physical design	PO1, PO3, PO5, PO9	C1, C3, C5, C6, P2, P6	Simulation, Experiment Coding, Group discussion, Project	Project report, Presentation, Viva

14.54.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓	✓	✓	✓	✓			✓		✓	✓						✓		✓

14.54.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Accessing Cadence Server, Tool Setup, Cell Library Creation, Introduction to Custom IC Design flow	CO1
2-7	Experiment 01-05	Creating different circuit schematics, Performing transient simulation, Power and delay measurement	CO2
8-9	Experiments 06	Layout of different circuits using Cadence Virtuoso	CO2
10-12	Project	Desing a given advanced circuit including hardware descriptive language (Verilog code), writing the test bench, synthesis, and physical design (PnR).	CO3
13	Project demonstration	Use multimedia and necessary documentation to communicate the project	CO3
14	Final Exam	Construct a circuit for a given problem based on the knowledge of the course.	CO1, CO2

14.54.7 Assessment Pattern/ Strategy

Assessment will be based on their successful completion of all experiments, by using Cadence Virtuoso simulator. There will be a final exam to complete a comprehensive circuit design and measurements, following a viva. The final project will be assessed based on their project outcome, presentation, viva and report.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.54.8 Text Books and Reference Books

1) CMOS VLSI Design, 3rd Edition, Neil Weste and David Harris, Addison Wesley.

2) Digital Systems, 12th Edition, Ronald Tocci, Neal Widmer and Greg Moss, Pearson.

14.55 Telecommunication Engineering

14.55.1 Introduction of the Course

Course Code and Title: 0714-EEE-4141: Telecommunication Engineering.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the fundamental principles and advanced techniques used in the transmission and switching of telecommunication signals. By covering a wide range of topics, students will be equipped with the knowledge and skills necessary to design, implement, and manage sophisticated telecommunication networks. The course emphasizes both theoretical foundations and practical applications, ensuring that graduates are well-prepared to meet the challenges and demands of the telecommunications industry.

Prerequisites (if any): 0714-EEE-3105: Communication Systems, 0714-EEE-3209: Communication Theory.

14.55.2 Course Objectives

The students are expected to

1) Gain a thorough understanding of the fundamental concepts in telecommunication systems and various types of transmission media used.

2) Identify and analyze common impairments to voice and data transmission.

3) Learn the process of speech digitization and transmission.

4) Understand multiplexing techniques, switching systems, and various stages of network switching.

5) Explore modern communication technologies such as IP telephony, VoIP, ISDN, SS7 etc.

14.55.3 Course Content

Introduction: Basic Concept of Electricity for Communication, Electrical Signals, Transmission of Electrical Signals – Wire Pair, Co-Axial Cable, Optical Fiber Cable, Radio Transmission, Voice and Data Transmission, Impairments to Voice Transmission-Amplitude Distortion, Phase Distortion, Noise, Simple Telephone Communication, Subscriber's Line Circuit, Two-Wire and Four-Wire Transmission, Multiplexing Techniques- TDM and FDM, Digital Signal Hierarchies in Telephone Systems – DS0, DS1, DS3, E1, E2, E3.

Switching Systems: Basic Switching System, Conventional Analog Switching, Types of Electromechanical Switches – Strowger and Crossbar Switch, Principles of Common Control, Touch Tone Dial Telephone, Crosspoint Technology, No. 1 ESS, Japanese D-10, Metaconta.

Signal Switching: Stored Program Control, Centralized SPC, Distributed SPC, Software Architecture, Application Software, Enhanced Services, Two-Stage Network, Three-Stage Network, N-Stage Network, Concepts of TDM, Basic Time Division Space Switching, Basic Time Division Time Switching, Time Multiplexed Space Switching, Time-Multiplexed Time Switching, Combination Switching, Three-Stage Combination Switching, N-Stage Combination Switching.

Speech Digitization and Transmission: Sampling, Quantization, Companding, Vocoders, Speech Model used in Vocoder Design.

Traffic Engineering: Traffic Characterization, Traffic Load, Loss Systems & Delay Systems, Grade of Service (GoS), Blocking Probability, Call Congestion and Time Congestion, Traffic Intensity, Modelling Switching Systems- Markov Processes and Birth-Death Processes, Blocking Models and Loss Estimates, Erlang B and C Formula, Quality of Service (QoS).

Telephone Networks: Subscriber Loop Systems, Switching Hierarchy and Routing, Transmission Plan, Transmission Systems, Numbering Plan, Charging Plan, Signalling Techniques, In-channel Signalling, Common Channel Signalling.

CCITT Signalling System No. 7 (SS7): Overview of SS7 Architecture, Relationship to OSI, Layer 1, 2 and 3, Signalling Network Structure, Signalling Performance, Numbering Plan, Signalling Connection Control Part (SCCP), User Part.

Integrated Services Digital Network (ISDN): N-ISDN and B-ISDN, Architecture of ISDN, B-ISDN Implementation.

Access Network Technologies: Digital Subscriber Loop (DSL), Wireless Local Loop (WLL), Hybrid Fiber Coax (HFC), Fiber to the X (FTTX), Ethernet Passive Optical Network (EPON), Gigabit PON (GPON).

Overview of IP Telephony, VoIP and Next Generation Network (NGN).

14.55.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Demonstrate a comprehensive understanding of the fundamental concepts in telecommunication systems and various transmission media	PO1, PO2	C1, C2	Lectures Discussions Handouts	Assignment Final Exam
CO2	Analyze and evaluate common impairments to voice and data transmission	PO4, PO6	C4, C6	Lectures Discussions Handouts	Incourse Final Exam
CO3	Gain knowledge of speech digitization processes	PO1, PO2, PO5	C1, C3, P3	Lectures Discussions Exercise	Assignment Final Exam
CO4	understand and apply multiplexing techniques and the functioning of various switching systems	PO1, PO3, PO5	C2, C3, P4	Lectures Discussions Handouts	Incourse Final Exam
CO5	Demonstrate proficiency in modern communication technologies and systems, and understand their integration within telecommunication networks	PO1, PO2, PO5, PO7	C1, C2, C5, P5	Lectures Discussions Handouts	Presentation Final Exam

14.55.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓			✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	

14.55.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction: Basic Concept of Electricity for Communication, Electrical Signals, Transmission of Electrical Signals – Wire Pair, Co-Axial Cable, Optical Fiber Cable, Radio Transmission.	CO1
2	3-4	Voice and Data Transmission: Impairments to Voice Transmission - Amplitude Distortion, Phase Distortion, Noise. Simple Telephone Communication, Subscriber's Line Circuit, Two-Wire and Four-Wire Transmission.	CO1, CO2
3	5-6	Multiplexing Techniques: TDM, FDM, Digital Signal Hierarchies in Telephone Systems – DS0, DS1, DS3, E1, E2, E3.	CO4
4	7-8	Switching Systems: Basic Switching System, Conventional Analog Switching, Electromechanical Switches - Strowger and Crossbar, Principles of Common Control, Touch Tone Dial Telephone, Crosspoint Technology.	CO4
5	9-10	Signal Switching: Stored Program Control (SPC), Centralized and Distributed SPC, Software Architecture, Application Software, Enhanced Services.	CO4
6	11-12	Speech Digitization: Sampling, Quantization, Companding, Vocoders, Speech Model used in Vocoder Design.	CO3
7	13-14	Traffic Engineering: Traffic Load, Loss Systems, Delay Systems, Grade of Service (GoS), Blocking Probability, Call and Time Congestion, Erlang B and C Formula, QoS.	CO2
8	15-16	Telephone Networks: Subscriber Loop Systems, Switching Hierarchy and Routing, Transmission Plan, Transmission Systems, Numbering Plan, Charging Plan.	CO1, CO4
9-10	17-20	Signalling Techniques: In-channel Signalling, Common Channel Signalling, CCITT Signalling System No. 7 (SS7) - Overview, Architecture, Layers 1-3, Signalling Network Structure, Signalling Performance, Numbering Plan, SCCP, User Part.	CO4, CO5
11	21-22	ISDN: N-ISDN and B-ISDN, Architecture of ISDN, B-ISDN Implementation.	CO5
12-13	23-26	Access Network Technologies: DSL, WLL, HFC, FTTX, EPON, GPON.	CO5
14	27-28	Overview of Modern Communication Technologies: IP Telephony, VoIP, and Next Generation Network (NGN).	CO5

14.55.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.55.8 Text Books and Reference Books

1) Digital Telephony, John C. Bellamy, Wiley Interscience.

2) Data Communications & Networking, Behrouz A. Forouzan, TATA McGraw-Hill.

3) Communication Networks, Alberto Leon-Garcia & Indra Widjaja, McGraw-Hill.

4) Voice over IP Technologies, Mark A. Miller, Wiley-Dreamtech.

5) Queueing Systems, Volume 1: Theory, Leonard Kleinrock, John Wiley & Sons.

6) Introduction to Queueing Theory, R.B. Cooper, Macmillan Press.

7) Telecommunication Networks: Devices, Circuits, and Systems, 1st Edition, Eugenio Iannone, CRC Press.

8) Telecommunication Switching Systems and Networks, Thiagarajan Viswanathan and Manav Bhatnagar, Prentice Hall.

9) Signaling in Telecommunication Networks, 2nd Edition, John G. van Bosse and Fabrizio U. Devetak, Wiley-Interscience.

10) Telecommunication Switching, Traffic and Networks, J. E. Flood, Pearson.

14.56 Optical Fiber Communication Systems and Networks

14.56.1 Introduction of the Course

Course Code and Title: 0714-EEE-4143: Optical Fiber Communication Systems and Networks.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of both fundamental and advanced concepts in optical fiber technology, the backbone of modern telecommunication systems. With the growing demand for high-speed, reliable, and large-capacity data transmission, expertise in optical fiber communication is becoming increasingly essential for engineers and technologists. This course equips students with the knowledge and practical skills to design, analyze, and implement optical communication systems and networks, covering topics such as fiber structures, modes of propagation, transmission characteristics, distortion and dispersion in optical fiber, optical sources and detectors, modulation techniques, and high-performance optical network architectures.

Prerequisites (if any): 0714-EEE-3105: Communication Systems, 0714-EEE-3207: Optoelectronics and Photonics.

14.56.2 Course Objectives

The students are expected to

1) Understand and explain the structural and modal characteristics of optical fibers, including the modal theory for circular waveguides.

2) Analyze the transmission characteristics of optical fibers, with a focus on signal degradation mechanisms, such as attenuation, distortion and dispersions, and explore techniques to minimize these effects.

3) Gain a comprehensive understanding of the operational principles and performance metrics of optical sources and optical detectors used in optical communication systems, along with their limitations.

4) Explore the functions and applications of various optical components, and understanding their roles in enhancing the performance of optical communication systems.

5) Develop the ability to design, analyze, and evaluate optical communication networks, including link power budgets, dispersion penalties, and power penalties, while incorporating advanced transmission technologies like Wavelength Division Multiplexing (WDM), Dense Wavelength Division Multiplexing (DWDM), and Orthogonal Frequency Division Multiplexing (OFDM), as well as understanding network architectures such as FDDI and SONET/SDH.

14.56.3 Course Content

Introduction: Optical Fibers, Structures, Step-Index and Graded-Index Fibers, Modes of Propagation, Modal Theory for Circular Waveguide, Modal Equations, Waveguide Equations, Power Flow in Optical Fibers, Fiber Materials, Mechanical Properties of Glass Fiber, Optical Fiber Cables.

Transmission Characteristics: Signal Degradation in Optical Fibers, Fiber Attenuation, Power Independent and Power Dependent Losses, Distortion in Optical Guides, Dispersions-Intermodal and Intramodal, Material and Waveguide Dispersion, Dispersion Compensating Fiber, Mode Coupling.

Optical Sources: Light Emitting Diode (LED) and Semiconductor Laser Diode (SLD), Structures, Emission Patterns and Spectral Width, Modulation Capability, Transient Response, Power Bandwidth Product, Modal Noise, Temperature Effects and Reliability, Single and Multi-Longitudinal Mode Laser Diodes.

Optical Detectors: PIN and Avalanche Photodetectors, Structures, Principles of Operations, Efficiency and Responsivity, Response Time, Photodetector Noise, Photodiode Materials.

Optical Components: Connectors, Couplers, Splicer, Isolators, Circulators, Filters: Thin Film Filters, Array Waveguide Gratings, Fiber Bragg Gratings.

Optical Amplifiers: Semiconductor Optical Amplifier (SOA), Erbium-Doped Fiber Amplifier (EDFA), EDFA Construction and Principle, Multi-Stage EDFA.

Optical Modulator and Receiver: Optical Modulation-Direct and External, Mach-Zehnder Modulator, Direct and Coherent Detection Receivers: Configuration, Operation, Noise Sources, Bit-Error-Rate and Sensitivity Calculation, Design of Analog and Digital Receivers.

Optical Networks: Link Power Budget, Fiber Link Design, Power and Dispersion Penalty, Wavelength Division Multiplexing (WDM), Dense Wavelength Division Multiplexing (DWDM) and Optical Frequency Division Multiplexing (OFDM) Transmission Schemes, Optical Data Coding, Optical Data Buses, Optical Networks, Fiber Distributed Data Interface (FDDI) and Synchronous Optical Network (SONET)/SDH.

14.56.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a thorough understanding of the structural and modal properties of optical fibers, and apply modal theory and waveguide equations in practical scenarios	PO1, PO2, PO3	C1, C2, C3	Lectures Handouts Discussions	Incourse Final Exam
CO2	Analyze the transmission characteristics of optical fibers, assess signal degradation, distortion, dispersion and propose solutions for attenuation and dispersion issues	PO2, PO4	C4, C5, C6	Lectures Handouts Discussions	Assignment Final Exam
CO3	Exhibit proficiency in the operational principles and	PO1, PO2, PO5	C1, C2, C3, C4	Lectures Handouts Discussions	Incourse Final Exam

	performance evaluation of optical sources and optical detectors, understanding their roles in optical communication systems				
CO4	Design, implement, and evaluate optical communication networks by effectively using various optical components, and by incorporating advanced network techniques	PO3, PO5, PO9	C5, C6, P3, P4, P5	Lectures Handouts Exercise	Assignment Final Exam

14.56.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓	✓			✓				✓	✓	✓	✓				

14.56.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-3	1-5	Introduction: Optical Fibers, Structures, Step-Index and Graded-Index Fibers Modes of Propagation, Modal Theory for Circular Waveguide, Modal Equations, Waveguide Equations, Power Flow in Optical Fibers Fiber Materials, Mechanical Properties of Glass Fiber, Optical Fiber Cables	CO1
3-5	6-10	Transmission Characteristics: Signal Degradation in Optical Fibers, Fiber Attenuation Power Independent and Power Dependent Losses, Distortion in Optical Guides Dispersions-Intermodal and Intramodal, Material and Waveguide Dispersion, Dispersion Compensating Fiber, Mode Coupling	CO2

6-8	11-15	Optical Sources: Light Emitting Diode (LED) and Semiconductor Laser Diode (SLD), Structures, Emission Patterns and Spectral Width Modulation Capability, Transient Response, Power Bandwidth Product, Modal Noise, Temperature Effects and Reliability Single and Multi-Longitudinal Mode Laser Diodes	CO3
8-9	16-17	Optical Detectors: PIN and Avalanche Photodetectors, Structures, Principles of Operation Efficiency and Responsivity, Response Time, Photodetector Noise, Photodiode Materials	CO3
9	18	Optical Components: Connectors, Couplers, Splicers, Isolators, Circulators	CO4
10	19	Filters: Thin Film Filters, Array Waveguide Gratings, Fiber Bragg Gratings	CO4
10-11	20-21	Optical Amplifiers: Semiconductor Optical Amplifier (SOA), Erbium-Doped Fiber Amplifier (EDFA), EDFA Construction and Principle, Multi-Stage EDFA	CO4
11	22	Optical Modulation: Direct and External, Mach-Zehnder Modulator	CO4
12	23-24	Direct and Coherent Detection Receivers: Configuration, Operation, Noise Sources Bit-Error-Rate and Sensitivity Calculation, Design of Analog and Digital Receivers	CO4
13	25-26	Optical Networks: Link Power Budget, Fiber Link Design, Power and Dispersion Penalty Wavelength Division Multiplexing (WDM), Dense Wavelength Division Multiplexing (DWDM), and Optical Frequency Division Multiplexing (OFDM) Transmission Schemes	CO4
14	27-28	Optical Data Coding, Optical Data Buses Fiber Distributed Data Interface (FDDI), Synchronous Optical Network (SONET)/SDH	CO4

14.56.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.56.8 Text Books and Reference Books

1) Optical Fiber Communications: Principles and Practice, 3rd Edition, John M. Senior, Pearson Education.

2) Optical Fiber Communications, 3rd Edition, Gerd Keiser, McGraw-Hill Higher Education.

3) Fiber-Optic Communication Systems, 3rd Edition, Govind P. Agrawal, John Wiley & Sons.

4) An Introduction to Fiber Optic Systems, 2nd Edition, John Powers, McGraw-Hill International Editions.

14.57 Optical Fiber Communication Laboratory

14.57.1 Introduction of the Course

Course Code and Title: 0714-EEE-4144: Optical Fiber Communication Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: The Optical Fiber Communication Laboratory offers hands-on experience in understanding, designing, and analyzing the key components and systems of optical fiber communication. This course enables students to explore the practical aspects of optical fibers, optical sources, detectors, and communication networks, equipping them with the skills to tackle real-world challenges in optical communication systems. The lab covers essential topics such as numerical aperture measurement, fiber attenuation, power distribution in single-mode fibers, mode distribution in multimode fibers, fiber coupling efficiency, and connector/splice losses. Additionally, students engage in the design, construction, and simulation of Wavelength Division Multiplexing (WDM) system components, bridging the gap between theoretical knowledge and practical applications in optical communication networks.

Prerequisites (if any): 0714-EEE-3105: Communication Systems, 0714-EEE-3106: Communication Systems Laboratory, 0714-EEE-3207: Optoelectronics and Photonics.

14.57.2 Course Objectives

The students are expected to

1) Develop practical skills in the design, analysis, and simulation of optical fiber communication systems through hands-on experiments with key components such as optical fibers, optical components, sources, detectors, and communication networks.

2) Gain proficiency in analyzing the effects of attenuation, dispersion, and noise on the performance and reliability of optical communication systems.

3) Design and evaluate optical transmitters and receivers to enable high-speed data transmission and Wavelength Division Multiplexing (WDM) applications.

4) Interpret and assess system performance using key metrics such as Bit Error Rate (BER), Eye Diagrams, and signal-to-noise ratio (SNR) to ensure system reliability.

5) Foster teamwork, critical thinking, and problem-solving skills by engaging in individual and group projects, preparing students to address real-world challenges in optical communication systems.

14.57.3 Course Content

Experiments in relevance with the EEE 4143 Optical Fiber Communication Systems and Networks course.

Projects related to EEE 4143 Optical Fiber Communication Systems and Networks course contents to achieve specific program outcomes.

14.57.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the effects of attenuation, distortion, dispersion, and bending losses in optical fibers.	PO1, PO2	C2	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva
CO2	Evaluate the performance of optical sources, detectors, and receivers through experimental analysis.	PO3, PO5	C5	Lectures, Simulation, Experiment	Lab reports, Lab test, Hardware demonstration
CO3	Design and analyze optical filters and WDM systems for multiplexing and demultiplexing applications.	PO2, PO4, PO5	C6	Lectures, Simulation, Experiment	Lab reports, Hardware demonstration Viva, Quiz

CO4	Analyze noise characteristics, BER, and Eye Diagrams to assess the performance of optical systems.	PO2, PO3	C4	Lectures, Simulation, Experiment	Lab reports, Lab test, Viva
CO5	Apply teamwork and laboratory skills to design and troubleshoot optical communication systems.	PO9, PO10, PO12	P3	---	Hardware demonstration Reports, Presentation

14.57.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
		✓		✓	✓		✓	✓				✓		✓		✓	✓		

14.57.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments; Formation of groups/teams for laboratory works	---
2	Experiment 01	To study the effects of attenuation and dispersion on the performance of OFC using multimode step index fiber.	CO1
3	Experiment 02	To determine bending radius for which a ray traveling along the fiber axis strike the cladding at the critical angle in the bend.	CO1
4	Experiment 03	To study the power and efficiency of LED in optical fiber communication.	CO2
5	Experiment 04	To study threshold gain, threshold current density and threshold current for laser diode.	CO2
6	Experiment	Review of Experiment 01 to 04	---
7	Experiment 05	Noise analysis of photodetector receiver.	CO3
8	Experiment 06	Design and performance analysis of an optical receiver for 10 Gbps transmission at 1550 nm using PIN or APD, TIA preamplifier and limiting amplifier.	CO3

9	Experiment 07	To analyze the BER and Eye Diagram in Optical Fiber Communication	CO4
10	Experiment 08	Design optical filters and analyze their frequency response for multiplexing and demultiplexing in WDM systems.	CO3, CO4
11	Experiment 09	Study the impact of shot noise, thermal noise, and signal-dependent noise on the performance of optical receivers using PIN or APD photodetectors.	CO3, CO4
12	Experiment	Review of Experiment 05 to 09	---
13-14	Examination	Final evaluation on Experiment 01 to 09	---

14.57.7 Assessment Pattern/ Strategy

Assessment will be based on the quality of experimental work, accuracy of data collection and analysis, adherence to procedures, teamwork, lab reports, and final evaluation through a practical examination and viva-voce.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.57.8 Text Books and Reference Books

1) Optical Fiber Communication Systems with MATLAB® and Simulink® Models, 2nd Edition, Le Nguyen Binh, CRC Press, Taylor & Francis Group.

2) Fiber Optics Lab Manual, Elias A. Awad, The Fiber Optic Association, Inc.

3) Fiber Optic Lab Manual, Fifth Edition, Industrial Fiber Optics.

14.58 Power System II

14.58.1 Introduction of the Course

Course Code and Title: 0713-EEE-4151: Power System II.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is a comprehensive course on power systems focusing on power transmission and distribution corridors and their mechanical design, stability analysis and control of power systems using modern power electronic based equipment. Knowledge obtained from this course will help students to work directly in any power system industry.

Prerequisites (if any): 0713-EEE-3201: Power System I.

14.58.2 Course Objectives

The students are expected to

1) Understand and design of physical parameters of overhead and underground transmission line.

2) Study and understand two axis models of synchronous machines and their loading capabilities.

3) Understand the basic concepts of stability, rotor angle and voltage stabilities, rotor dynamics and their applications to analyze and understand stability, voltage-power profile of network and their relationship with voltage collapse.

4) Understand the operation and demonstrate applications of HVDC systems.

5) Understand the operation and demonstrate applications of FACTS devices.

6) Study and understand power quality issues and their characteristics and improvement techniques.

14.58.3 Course Content

Power Transmission/Distribution Paths: Overhead Transmission Lines, Underground/ Underwater Cables, and their Mechanical Designs.

Modelling of Machines: Two Axes Model of Machines, Load Capability of Generators (Conventional and Renewable Based).

Power System Stability: Overview on Steady-State and Dynamic Behaviour of Power Systems, Classification of Stability, Rotor Angle Stability- Swing Equation, Power Angle Equation, Equal Area Criterion, Multi-Machine System, Factors Affecting Stability.

Voltage Stability: Basic Concepts Related to Voltage Stability, Voltage Collapse Phenomena, Static Analysis of Voltage Stability-V/Q Sensitivity Analysis, Q/V Modal Analysis.

Flexible AC Transmission System (FACTS): Introduction, SVC, STATCOM, SSSC, TCSC, TCSR, TCPST, UPFC, IPFC, DVR.

High Voltage DC (HVDC) Transmission System: Types of HVDC, Its Components and Operations.

Power Quality: Voltage Sag/Swell, Harmonics, Surges, Inter-Harmonics, Flicker, Grounding Problems, Mitigation Techniques, Power Quality Standards.

14.58.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain and analyze the design parameters of the overhead and underground	PO1, PO2	C1, C2, C4	Lectures Discussions Handouts	Assignment Incourse Final Exam

	transmission lines, and their mechanical design.				
CO2	Apply knowledge of mathematics and electrical circuits to model synchronous machines.	PO3	C2, C3	Lectures Discussions	Assignment Incourse Final Exam
CO3	Understand and investigate power system stability including rotor angle and voltage stabilities using engineering tools.	PO1, PO4, PO5	C1, C2, C4, C5	Lectures Discussions	Assignment Incourse Final Exam
CO4	Study and understand modern power system equipment, and power quality issues	PO1	C1, C2	Lectures Discussions	Assignment Incourse Final Exam
CO5	Investigate the techniques and design systems to improve power quality, reliability, and voltage profile	PO3, PO4, PO5	C3, C4, C6	Lectures Discussions	Assignment Incourse Final Exam

14.58.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓			✓	✓	✓						✓		✓	

14.58.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-3	Overhead Transmission Lines: design and Inductance calculation	CO1

2-3	4-5	Overhead Transmission Lines: design and capacitance calculation	CO1
3-4	6-8	Underwater Cables	CO1
5-6	9-11	Mechanical Design of transmission lines	CO1
6-7	12-13	Modelling of Machines: Two Axes Model of Machines, Load Capability of Generators (Conventional and Renewable Based).	CO2
7-9	14-18	Power System Stability: Overview on Steady-State and Dynamic Behaviour of Power Systems, Classification of Stability, Rotor Angle Stability- Swing Equation, Power Angle Equation, Equal Area Criterion, Multi-Machine System, Factors Affecting Stability.	CO3
10-11	19-21	Voltage Stability: Basic Concepts Related to Voltage Stability, Voltage Collapse Phenomena, Static Analysis of Voltage Stability-V/Q Sensitivity Analysis, Q/V Modal Analysis.	CO3
11-12	22-23	High Voltage DC (HVDC) Transmission System: Types of HVDC, Its Components and Operations.	CO1, CO5
12-13	24-26	Flexible AC Transmission System (FACTS): Introduction, SVC, STATCOM, SSSC, TCSC, TCSR, TCPST, UPFC, IPFC, DVR.	CO4, CO5
14	27-28	Power Quality: Voltage Sag/Swell, Harmonics, Surges, Inter-Harmonics, Flicker, Grounding Problems, Mitigation Techniques, Power Quality Standards.	CO4, CO5

14.58.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.58.8 Textbooks and Reference Books

1) Power System Analysis by John J. Grainger and William D. Stevenson, McGraw Hill.

2) Elements of Power System Analysis, William D. Stevenson, McGraw-Hill.

3) High Voltage Engineering Fundamentals, 2nd Edition, by John Kuffel and Peter Kuffel, Newnes.

4) Power System Stability and Control, 1st Edition, Prabha Kundur, McGraw Hill.

5) Modern Power System Analysis, 2nd Edition, Toran Gonen, CRC Press.

6) Electric Power Engineering Handbook, Leonard L. Grigsby, CRC Press.

7) HVDC and FACTS Controllers, Vijay K. Sood, Springer.

8) High Voltage Engineering, 1st Edition, Farouk A.M. Rizk and Giao N. Trinh, CRC Press.

9) High Voltage Direct Current Transmission: Converters, Systems and DC Grids, 1st Edition, Dragan Jovcic and Khaled Ahmed, Wiley.

10) Power Systems Analysis, T.K. Nagsarkar and M.S. Sukhija, Oxford University Press.

11) Power System Analysis and Design, 6th Edition, J. Duncan Glover, Thomas Overbye and Mulukutla S. Sarma, Cengage Learning.

12) Power Systems Analysis, 2nd Edition, Arthur R. Bergen and Vijay Vittal, Pearson.

14.59 Power System Protection

14.59.1 Introduction of the Course

Course Code and Title: 0713-EEE-4153: Power System Protection.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course equips students with comprehensive knowledge and practical skills in power system protection, ensuring they can effectively detect and mitigate faults, configure and utilize various protection relays, implement unit protection schemes for diverse power system components, and understand the principles and selection criteria for different types of circuit breakers. This foundational expertise is essential for maintaining electrical power systems' reliability, stability, and safety.

Prerequisites (if any): 0713-EEE-3201: Power System I.

14.59.2 Course Objectives

The students are expected to

1) Develop a foundational understanding of power system protection.

2) Analyze and configure various relays.

3) Understand the principles, types, and applications of circuit breakers

4) Investigate unit protection schemes.

14.59.3 Course Content

Introduction: Purpose of Power System Protection, Criteria for Detecting Faults: Over Current, Differential Current, Difference of Phase Angles, Over and Under Voltages, Power Direction, Symmetrical Components of Current and Voltages, Impedance, Frequency and Temperature, Instrument Transformers: CT and PT.

Electromechanical, Electronic, and Digital Relays: Basic Modules, Over Current Relays, Distance Relays, Directional Relays, Inverse Definite Minimum Time (IDMT) Relays, Differential and Percentage Differential Relays, Pilot Relays, Wire Pilot Carrier, Trip Circuits.

Unit Protection Schemes: Generator, Transformer, Motor, Bus Bar, Transmission and Distribution Lines, HVDC System and Feeders.

Circuit Breakers: Principle of Arc Extinction, Transient Recovery Voltage, Selection Criteria and Ratings of Circuit Breakers, Types - Miniature Circuit Breaker (MCB), Molded Case Circuit Breaker (MCCB), Air Circuit Breaker (ACB), Air Blast Circuit Breaker (ABCB), Vacuum Circuit Breaker (VCB), Oil Circuit Breaker (OCB), Minimum Oil Circuit Breaker (MOCB) and Sulfur Hexafluoride (SF6) Circuit Breaker.

14.59.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand criteria and techniques for detecting faults using current, voltage, phase angles, impedance, and temperature measurements.	PO1, PO2	C1, C2, A1	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO2	Gain proficiency in using and configuring electromechanical, electronic, and digital relays for various protection applications.	PO2, PO3	C3, C4, C5	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO3	Learn to implement protection schemes for generators, transformers, motors, bus bars, transmission lines, and HVDC systems.	PO3, PO5, PO6	C3, C5	Lectures Discussions Exercise	Assignment Incourse Final Exam

CO4	Understand the principles, types, and selection criteria of circuit breakers for effective power system protection	PO2, PO5	C4, C5	Lectures Discussions Exercise	Assignment Incourse Final Exam

14.59.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓	✓	✓			✓		✓	✓		✓	✓	✓	✓		✓	

14.59.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	Cos
1-2	1-4	Introduction: Purpose of Power System Protection Criteria for Detecting Faults: Over Current, Differential Current, Difference of Phase Angles, Over and Under Voltages, Power Direction, Symmetrical Components of Current and Voltages, Impedance, Frequency and Temperature	CO1
3	5-6	Instrument Transformers: CT and PT	CO1
4-8	7-16	Electromechanical, Electronic and Digital Relays: Basic Modules, Over Current Relays, Distance Relays, Directional Relays, Inverse Definite Minimum Time (IDMT) Relays, Differential and Percentage Differential Relays, Pilot Relays, Wire Pilot Carrier, Trip Circuits.	CO2
9-10	17-19	Circuit Breakers: Principle of Arc Extinction, Transient Recovery Voltage, Selection Criteria and Ratings of Circuit Breakers, Types - Miniature Circuit Breaker (MCB), Molded Case Circuit Breaker (MCCB), Air Circuit Breaker (ACB)	CO4
10-11	20-22	Air Blast Circuit Breaker (ABCB), Vacuum Circuit Breaker (VCB), Oil Circuit Breaker (OCB), Minimum Oil Circuit Breaker (MOCB) and Sulfur Hexafluoride (SF6) Circuit Breaker.	CO4
12-14	23-28	Unit Protection Schemes: Generator, Transformer, Motor, Bus Bar, Transmission and Distribution Lines, HVDC System and Feeders.	CO3

14.59.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum of 1 Assignment and/or presentation; if 2 or more assignments or presentations are taken then their average will be considered in the final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.59.8 Text Books and Reference Books

1) Power System Protection, 1st Edition, Paul M. Anderson, Wiley and IEEE Press.

2) Protection of Industrial Power Systems, 2nd Edition, T. Davies, Elsevier.

3) Fundamentals of Power System Protection, Y.G. Paithankar and S.R. Bhide, Prentice Hall.

4) Practical Power Systems Protection, Les Hewitson, Mark Brown Senior Staff Engineer and Ben Ramesh, Elsevier.

5) Protective Relaying: Principles and Applications, 4th Edition, J. Lewis Blackburn and Thomas J. Domin, CRC Press.

6) Power System Protective Relaying, 1st Edition, J C Das, CRC Press.

14.60 Power System Protection Laboratory

14.60.1 Introduction of the Course

Course Code and Title: 0713-EEE-4154: Power System Protection Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: Provide students with practical skills to ensure efficient functioning and troubleshooting of electrical protection systems.

Prerequisites (if any): 0713-EEE-3201: Power System I.

14.60.2 Course Objectives

The students are expected to

1) Implement and troubleshoot various electrical protection systems including relays, fuses, and circuit breakers.

2) Develop students' practical experience and operational knowledge while gaining hands-on exposure to substation equipment, safety protocols, and real-world electrical systems applications.

14.60.3 Course Content

Experiments in relevance with the 0713-EEE-4153: Power System Protection course.

14.60.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Identify and use lab equipment safely, conduct experiments, and manage projects.	PO5	C1, C2, A1	Lectures, Experiment	Assignment/ reports, Lab tests, Quiz, Viva
CO2	Understand, configure, and troubleshoot under/over-voltage and over-current protection using time and inverse time relays.	PO2, PO5	C2, C5, A1	Lectures, Experiment	Assignment/ reports, Lab tests, Quiz, Viva
CO3	Implement and analyze earth fault, differential, distance, and directional relays for transformer and transmission line protection.	PO2, PO5	C2, C5, A1	Lectures, Experiment	Assignment/ reports, Lab tests, Quiz, Viva
CO4	Address unbalanced loads with feeder manager relays, and understand the use and selection of fuses and circuit breakers.	PO2, PO5	C2, C5, A1	Lectures, Experiment	Assignment/ reports, Lab tests, Quiz, Viva
CO5	Develop practical experience and	PO5	C4, C5, A1, A2	Lectures, Field Visit	Assignment/ reports, Lab

	operational knowledge of substation equipment, safety protocols, and real-world applications of electrical systems.				tests, Quiz, Viva

14.60.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
				✓	✓	✓		✓		✓	✓				✓	✓			

14.60.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction to the laboratory equipment and overview of experiments and projects	CO1
2	Experiment 01	Under/over voltage protection using time relay	CO2
3	Experiment 02	Over-current protection using definite time over current relay	CO2
4	Experiment 03	Over-current protection using inverse time over-current relay	CO2
5	Experiment 04	Earth fault relay	CO3
6	Experiment 05	Transformer protection using differential relay	CO3
7	Experiment 06	Protection of transmission lines using distance protection relay	CO3
8	Experiment 07	Transformer protection from the unbalanced load using feeder manager relay	CO4
9	Experiment 08	Unbalanced protection of transmission line	CO4
10	Experiment 09	Directional protection in transmission lines using directional relay	CO3
11	---	Study of different fuses, and circuit breakers	---
12	---	Site visit e.g. substation	---
13	---	Quiz	---
14	---	Viva	---

14.60.7 Assessment Pattern/ Strategy

Assessment will be based on evaluating students' comprehension of laboratory equipment, implementation of relay-based protection systems, understanding of fuses and circuit breakers, and practical insights gained from a field visit.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.60.8 Text Books and Reference Books

1) Sunil S Rao, "Switchgear Protection & Power Systems", Khanna Publishers

2) Fundamentals of Power System Protection, Y.G. Paithankar and S.R. Bhide, Prentice Hall.

3) Practical Power Systems Protection, Les Hewitson, Mark Brown Senior Staff Engineer and Ben Ramesh, Elsevier.

14.61 Computer Organization and Architecture

14.61.1 Introduction of the Course

Course Code and Title: 0612-CSE-4161: Computer Organization and Architecture.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a deep understanding of the fundamental principles and structures that underlie modern computer systems. In an era where computing technology is advancing rapidly, this course is essential for students pursuing degrees in computer science, computer engineering, or related fields. It not only equips them with theoretical insights but also encourages practical applications and critical thinking, ensuring their readiness for the challenges of the ever-evolving field of computing.

Prerequisites (if any): 0714-EEE-2103: Digital Electronics, 0714-EEE-3103: Microprocessor and Interfacing.

14.61.2 Course Objectives

The students are expected to

1) Develop a strong foundation in the principles of computer organization and architecture.

2) Explore the components that constitute a computer system, such as the CPU, memory, input/output devices, and interconnection structures.

3) Understand the organization of memory systems, including internal and external memory, cache memory, and virtual memory.

4) Explore the design and operation of Central Processing Unit (CPU), Arithmetic Logic Unit (ALU) and control units.

5) Introduce techniques for achieving high performance, including RISC and CISC architectures, parallel processing, and vector processing.

14.61.3 Course Content

Computer System: Computer Organization, Structure and Function, System Buses, Interconnection Structure.

Memory System: Memory System Overview, Internal and External Memory, Memory Chip Organization and Error Correction, Cache Memory and its Mapping Functions, Virtual Memory Management, Memory Storage Devices.

Input/Output: I/O Devices, I/O Modules, Programmed and Interrupt-Driven I/O, Direct Memory Access (DMA).

CPU/ALU: Integer and Floating Point Arithmetic, Signed Operand Multiplication, Fast Multipliers, Instruction Sets, Types of Operands, Addressing Modes, CPU Structure and Functions, Process Organization, Register Organization, Instruction Cycle, Instruction Pipelining, Arithmetic and Logic Unit (ALU), Bit Sliced ALU.

Control Unit: Micro-Operations, Hardwired Control Unit, Control Unit Operation, Micro-Instruction Sequencing and Execution, Grouping of Signals, Micro- Programmed Control Unit, Microprogram Sequencing.

High Performance Computer System: Techniques to Achieve High Performance, RISC, CISC, Introduction to Superscalar Processor, Parallel Processor, Array Processor, Multi-Programming, Vector Processing, Fault Tolerant Computing, High Performance Scientific Computing.

14.61.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Analyze and design components of a computer system, and their interconnection	PO3	C4	Lectures Handouts Discussions	Assignment Incourse Final Exam
CO2	Understand and implement memory management systems	PO5	C2	Lectures Handouts	Assignment Presentation Final Exam
CO3	Describe and analyze the operations of the CPU, ALU, and	PO1	C2	Lectures Handouts Discussions	Presentation Final Exam

	control units in computer systems				
CO4	Apply and evaluate techniques for achieving high performance in computer systems	PO3	C6	Lectures Handouts	Incourse Final Exam

14.61.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓		✓			✓			✓	✓	✓					✓	✓	✓		

14.61.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Computer Organization and Architecture, Structure and Function, Computer Components, Instruction Fetch and Execute	CO1
2	3-4	Interrupts, I/O Function, Interconnection Structures, Bus Interconnection, Point-to-Point Interconnect, PCI (Peripheral Component Interconnect) Express (PCIe)	CO1
3-4	5-8	Characteristics of Memory Systems, Memory Hierarchy, Cache Memory Principle, Elements of Cache Design, Mapping Function, Replacement Algorithms, Write Policy, Line Size, Number of Caches	CO2
5-6	9-12	Main Memory Organization, DRAM and SRAM, Types of ROM, Chip Logic, Module Organization, Error Correction, DDR DRAM, Flash Memory, Magnetic Disk, Solid State Drives, Optical Memory, Compact Disk	CO2
7	13-14	External Devices, I/O Modules, Programmed I/O, Interrupt-Driven I/O, Intel 82C59A Interrupt Controller,	CO3
8	15-16	Intel 8255A Programmable Peripheral Interface, Direct Memory Access (DMA), Intel 8237A DMA Controller	CO1 CO2
9-10	17-20	Arithmetic and Logic Unit, Integer Representation, Integer Arithmetic, Machine Instruction Characteristics, Types of Operands, Intel x86 Data Types	CO3
11	21-22	Addressing Modes, Intel x86 Addressing Modes, Processor Organization, Register Organization	CO2

12	23-24	Instruction Cycle, Instruction Pipelining, Intel 80486 Pipelining	CO4
13	25-26	Micro-Operations, Control of the Processor, Hardwired Implementation, Microinstructions, Microinstruction Sequencing, Microinstruction Execution	CO4
14	27-28	Reduced Instruction Set Computers (RISC), RISC/CISC Evolution Cycle, RISCs Design Principles, Overlapped Register Windows, RISCs Versus CISCs, Parallel and Multiprocessor Architectures, Superscalar, Vector Processors	CO4

14.61.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.61.8 Text Books and Reference Books

1) Computer Organization and Architecture, 10th Edition, William Stallings, Pearson.

2) Computer Architecture: A Quantitative Approach, John L. Hennessy and David A. Patterson, Morgan Kaufmann.

3) Inside the Machine: An Illustrated Introduction to Microprocessors and Computer Architecture, 1st Edition, Jon Stoke, No Starch Press.

4) Computer Organization and Design: The Hardware/Software Interface, 5th Edition, David A. Patterson and John L. Hennessy, Morgan Kaufmann.

5) Computer Organization and Embedded Systems, 6th Edition, Carl Hamacher, Vranesic, Zaky Zvonko, Safwat Engin and Naraig Manjikian, McGraw-Hill Education.

14.62 Data and Computer Network

14.62.1 Introduction of the Course

Course Code and Title: 0612-CSE-4163: Data and Computer Network.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: As our world becomes increasingly interconnected, the need for robust, efficient, and secure data communication networks is more crucial than ever. This course provides students with the foundational and advanced knowledge needed to design, implement, and maintain data and computer networks that are resilient, efficient, and secure. Covering a wide range of topics, from the basics of network topologies to advanced security protocols, this course equips students with the tools to navigate and innovate within the rapidly evolving landscape of network technology.

Prerequisites (if any): No prerequisite.

14.62.2 Course Objectives

This course provides the student with an understanding of how data and computer networks operate: how packets are transmitted, how packets are routed, what to do when there is network congestion etc. The students will study International Standards Organization Open System Interconnection (ISO-OSI) reference model, design issues and protocols in the physical layer, data link layer, network layer and transport layer; architectures and control algorithms of local area networks & point-to-point networks; standards in network access protocols; models of network interconnection, and overview of networking and communication software.

The students are expected to

1) Gain a solid grounding in network topologies, OSI and TCP/IP reference models, and key network types (LAN, MAN, WAN), enabling students to design efficient and scalable networks.

2) Develop the ability to implement analog and digital data transmission methods, comprehend channel capacity, and evaluate different transmission media, including twisted-pair cables, fiber optics, and wireless media.

3) Learn various data link layer protocols, including error detection, error correction, and multiple access protocols, to manage data flow and ensure reliability in network communications.

4) Acquire a comprehensive understanding of routing algorithms, IP addressing (IPv4, IPv6), and encryption methods, enabling students to design secure networks that meet industry standards for performance and security

14.62.3 Course Content

Data Communication Networking: Data Communication Model, Network Topologies, Protocol Layer Architecture, OSI Reference Architecture, TCP/IP Reference Architecture, Local Area Network (LAN), Metropolitan Area Network (MAN) and Wide Area Network (WAN), Circuit Switching Versus Packet Switching, Datagram and Virtual Circuits, LAN, MAN and WAN Standards, Network Interconnections – Bridges, Hubs, Switches, Routers and Gateways.

Physical Layer and Media: Analog and Digital Data Transmission, Spectrum and Bandwidth, Data Rate and Channel Capacity, Transmission Impairments, Twisted- Pair, Co-Axial and Fiber-Optic Cable, Wireless Media; Multiplexing – Frequency Division Multiplexing, International FDR Carrier Standards, Synchronous Time Division Multiplexing and International TDR Carrier Standards, Statistical TDM and Wavelength

Division Multiplexing, Digital Data, Digital Signals: Signal Encoding Schemes – NRZ, NRZ-L, NRZI, Bipolar-AMI and Pseudoternary, Manchester and Differential Manchester, B8ZS, HDB3, etc.

Data Link Layer: Asynchronous and Synchronous Transmission, Flow Control and Error Control, Data Link Layer Protocols – Stop-and-Wait Flow Control, Sliding Window Flow Control, Stop-and-Wait ARQ, Go Back N ARQ, Selective Repeat ARQ, Error Detection and Error Correction, HDLC, PPP, Medium Access Control (MAC) Sublayer: Multiple Access Protocols – ALOHA, CSMA, CSMA/CD, Binary Exponential Backoff Algorithm, MACA; IEEE802.2 LLC.

Network Standards: IEEE 802.3 (Ethernet) Specifications, Fast Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, IEEE802.11 (WiFi) Protocol Architecture, Physical Layer, MAC Sublayer, IEEE 802.16 (WiMAX) Standard, Frame Relay, ATM.

Network Layer: Network Layer Design Issues – Store and Forward Packet Switching, Implementation of Connectionless Service, Implementation of Connection-Oriented Service, Routing Algorithms – The Optimality Principle, Shortest Path Routing, Flooding, Distance Vector Routing, Link State Routing, Broadcast and Multicast Routing, Routing in Ad-Hoc Networks, Congestion Control, QoS, Network Layer in the Internet – The Internet Protocol (IP), IP Address, IPv4, IPv6, Mobile IP, Internet Control Protocols – ICMP, ARP, RARP, DHCP, OSPF, BGP.

Transport Layer: The Transport Service, UDP, TCP, TCP Congestion Control.

Network Security: Introduction to Network Security, Encryption – DES, AES, Public Key Encryption and Digital Signatures, IP Security, Authentication Protocols.

14.62.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the fundamentals of network architecture and protocols	PO1	C2, P1	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO2	Analyze and apply data transmission techniques	PO2	C3, C4	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO3	Implement data link layer protocols and flow control mechanisms	PO3	C3, P4	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO4	Explore advanced network layer, transport layer	PO4	C1	Lectures, Discussion, Handout	Assignment In-course Final Exam

	and security protocols				

14.62.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
			✓	✓	✓			✓	✓			✓			✓	✓		✓	

14.62.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Data communications, network models, protocols and standards	CO1
2-3	3-6	Physical Layer and Media: Data signals, digital transmission, Analog transmission, Bandwidth utilization, multiplexing and spreading, Transmission media, Switching, Telephone and Cable networks for data transmission.	CO2
4-5	7-10	Data Link Layer: Error detection and correction, Data Link control, Multiple access	CO3
6-8	11-16	Network Standards: Wired LANs, Wireless LANs, Virtual LANs, WiMAX, Frame Relay and ATM	CO4
9-10	17-20	Network Layer: Logical addressing, Internet protocol, IPv4 vs IPv6, Address mapping, Error reporting and multicasting, Delivery, forwarding and routing	CO4
11-12	21-24	Transport Layer: Process to process delivery, UDP, TCP and Congestion control	CO4
13-14	25-28	Network Security: Introduction to network security, Encryption – DES, AES, Public key encryption and digital signatures, IP security, Authentication protocols	CO4

14.62.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.62.8 Text Books and Reference Books

1) Communication Networks, Alberto Leon-Garcia & Indra Widjaja, McGraw-Hill.

2) Computer Networks & Internets with Internet Applications, Douglas E. Comer, Pearson Education.

3) High-Speed Networks and Internets: Performance and Quality of Service, William Stallings, Prentice-Hall.

4) Data and Computer Communications, 10th Edition, William Stalling, Pearson.

5) Data Communications and Networking, 5th Edition, Behrouz A. Forouzan, McGraw-Hill Education.

6) Computer Networks, 6th Edition, Andrew S. Tanenbaum and David J. Wetherall, Pearson.

7) Computer Networking: A Top-Down Approach, 8th Edition, James Kurose and Keith Ross, Pearson.

8) Computer Networks: A Systems Approach, 5th Edition, Larry L. Peterson and Bruce S. Davie, Morgan Kaufmann.

14.63 Data and Computer Network Laboratory

14.63.1 Introduction of the Course

Course Code and Title: 0612-CSE-4164: Data and Computer Network Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: The Data and Computer Network Laboratory course is designed to provide students with practical, hands-on experience that complements the theoretical knowledge acquired in 0612-CSE-4163: Data and Computer Network course. In the contemporary landscape of information technology, practical skills in network setup, management, and troubleshooting are essential for success in the field. This laboratory course facilitates an experiential learning environment where students can directly engage with real equipment, simulation tools, software and technologies that underpin modern communication networks.

Prerequisites (if any): No prerequisite.

14.63.2 Course Objectives

The students are expected to

1) Gain hands-on experience in configuring and managing network devices such as routers, switches, and access points, and setting up protocols like TCP/IP, Ethernet, and WiFi.

2) Design, set up, and troubleshoot local and wide area networks using industry tools and standards, applying concepts of topology, switching, and routing to achieve optimal network performance

3) Implement and analyze routing algorithms, such as Distance Vector and Link State, and protocols like IPv4 and IPv6, to gain a practical understanding of data forwarding and routing decisions.

4) Develop skills in diagnosing and resolving network issues, using tools such as packet analyzers and network monitoring software to identify and mitigate connectivity and performance problems.

5) Address real-world case studies and challenges, preparing students to think critically and apply their knowledge to solve practical networking problems encountered in industry settings.

14.63.3 Course Content

Experiments in relevance with the EEE 4163 Data and Computer Network course.

Projects related to EEE 4163 Data and Computer Network course contents to achieve specific program outcomes.

14.63.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Develop proficiency in configuring network devices and protocols	PO1, PO3	C1, C6, P4	Experiment, Project	Lab reports, Lab test, Viva, Project
CO2	Configure and troubleshoot LAN and WAN setups	PO2, PO4	C3, C4	Experiment, Simulation	Lab reports, Hardware demonstration
CO3	Explore routing algorithms and network layer protocols	PO4, PO5	C1	Simulation, Experiment	Lab reports, Lab demonstration, Lab test, Viva
CO4	Understand and implement network troubleshooting practices	PO5	C3, P4	Experiment, Simulation, Project	Lab/Project reports, Hardware/Project demonstration, Lab test, Viva

CO5	Prepare for real-world networking challenges	PO6	P2	Experiment, Simulation, Project	Lab/Project reports, Hardware/Project demonstration, Lab test, Viva

14.63.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓	✓	✓		✓			✓	✓		✓		✓		✓	✓		✓	

14.63.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Experiment 01	Introduction to networking devices	CO1
2	Experiment 02	Introduction to networking cables and connection.	CO2
3	Experiment 03	Introduction to packet tracer and packet tracer CLI commands.	CO1, CO2
4	Experiment 04	Create a Simple Network Using Packet Tracer	CO1, CO2
5	Experiment 05	Basic Router Configuration	CO3, CO5
6	Experiment 06	Subnet and Router Configuration	CO3, CO5
7	Experiment 07	Challenge Static Route Configuration	CO3, CO5
8	Experiment 08	Basic RIP Configuration	CO3, CO5
9	Experiment 09	Basic EIGRP Configuration	CO3, CO5
10	Experiment 10	Introduction to DHCP on packet tracer	CO3, CO5
11	Experiment 11	DHCP on packet tracer through Server	CO3, CO5
12	Lab Final Exam	Show evidence that specific technical skills have been attained by the students	CO4, CO5

13	Project demonstration	Present/demonstrate the technical progress of the project; Describe multidisciplinary aspects of the project	CO4, CO5
14	Final presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence that specific technical requirements have been attained by the project	CO4, CO5

14.63.7 Assessment Pattern/ Strategy

Assessment will be based on successful completion of the experimental work, project design, implementation and demonstration of the specific technical skills attained throughout the course.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.63.8 Text Books and Reference Books

1) Data and Computer Communications, 10th Edition, William Stalling, Pearson.

2) Data Communications and Networking, 5th Edition, Behrouz A. Forouzan, McGraw-Hill Education.

3) Computer Networks, 6th Edition, Andrew S. Tanenbaum and David J. Wetherall, Pearson.

4) Computer Networking: A Top-Down Approach, 8th Edition, James Kurose and Keith Ross, Pearson.

14.64 Project Work

14.64.1 Introduction of the Course

Course Code and Title: 0714-EEE-4100: Project Work.

Credits and Contact Hours: 2.0 Credits, 4 Contact Hours per Week.

Rationale of the Course: In an ever-evolving landscape of electrical and electronic engineering, this course stands as a cornerstone, providing students with a transformative learning experience. This course is meticulously designed to instill a deep sense of inquiry, research acumen, and practical application within the field. By immersing themselves in the intricacies of their chosen research topics, students emerge not only with academic knowledge but with the practical skills and ethical grounding needed to excel in their future careers.

Prerequisites (if any): No prerequisite.

14.64.2 Course Objectives

The students are expected to

1) Acquire the ability to formulate and execute a comprehensive research plan within the scope of electrical and electronic engineering.

2) Navigate and critically review relevant research literature to establish a theoretical foundation.

3) Identify and define specific problems within the chosen research topic.

4) Formulate well-structured and innovative proposals to address identified issues.

5) Develop and deliver a concise and effective technical presentation that conveys complex information to both technical and non-technical audiences.

6) Acquire and apply project management skills to develop a detailed research plan, ensuring efficient execution of research activities within specified timelines.

14.64.3 Course Content

Students will engage in theoretical investigations focusing on a research topic within the field of electrical and electronic engineering. Throughout the course, students will review relevant research literature, explore contemporary aspects of the chosen topic, identify problems, and formulate proposals to address specific issues related to the subject matter. In the upcoming semester, they will persist in conducting simulations and/or experiments, analyzing and interpreting data, and synthesizing information to draw valid conclusions.

Additionally, students will be expected to comprehend and adhere to professional ethics and ethical principles of research.

14.64.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate the ability to deliver concise and effective technical presentations	PO10	A2	Discussion Experiment Simulation	Report Presentation
CO2	Acquire skills in identifying specific problems and formulating innovative and well-structured proposals to address these issues	PO2	C4, P6		

CO3	Attain proficiency in project management	PO9, PO11	C3, P7		
CO4	Exhibit a strong understanding of professional ethics and ethical principles of research	PO6, PO8	A3, A5		

14.64.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓				✓	✓	✓	✓	✓				✓	✓	✓	✓		✓

14.64.6 Course Structure/ Lecture Plan

Weekly meeting and discussion with supervisor regarding project work.

Final Week of the Semester: 1) Project report submission
2) Oral presentation of the project work

14.64.7 Assessment Pattern/ Strategy

At the end of the semester, each student is required to submit a comprehensive project report for evaluation. Additionally, each student must orally present their project work, and respond to questions from both examiners and the audience.

Distribution of marks:

Project Report	50%
Project Presentation	50%
Total	100%

14.64.8 Text Books and Reference Books

N/A

14.65 Control Engineering

14.65.1 Introduction of the Course

Course Code and Title: 0714-EEE-4201: Control Engineering.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Control mechanisms are an inextricable part of any functioning system. Not a single system, whether electrical, electronic, mechanical, or of any type, is found that does not involve some kind of control mechanism these days. Therefore, the B.Sc. level Control Engineering course is one of the foundational courses in the Department of Electrical and Electronic Engineering. This course aims to produce graduates with the knowledge and skills needed to design, analyze, and implement control systems in various engineering applications.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0541-MAT-1105: Differential and Integral Calculus.

14.65.2 Course Objectives

The Control Engineering course is designed to provide students with a strong foundation in the principles and applications of control systems. This course focuses on model-based control system analysis and optimization.
The students are expected to

1) Be able to model a physical system and analyze transient and steady-state response of the system.

2) Know the methods of time domain and frequency domain response of a system.

3) Identify different parameters to improve the stability of the system response.

14.65.3 Course Content

Introduction: Introduction to Control Systems, Definitions and Mathematical Background.

Writing System Equations: State Concepts, Transfer Function and Block Diagram, Mechanical Translation Systems, Mechanical Rotational Systems.

Solution of Differential Equations: Standard Inputs to Control Systems, Steady- State Response and Transient Response.

Laplace Transform: Definition, Laplace Transform Theorems, Application of The Laplace Transforms to Differential Equations, Inverse Transformation, Heavi- side Partial-Fraction Expansion Theorems.

System Representation: Block Diagrams, Determination of the Overall Transfer Function, Standard Block Diagram Terminology, Simulation Diagrams, Signal Flow Graphs.

Control System Characteristics: Routh-Hurwitz Stability Criterion, Feedback System Types, Analysis of System, Types, Steady-Mate Error Coefficients, Non Unity-Feedback System.

Root Locus: Plotting Roots of a Characteristics Equation, Qualitative Analysis of the Root Locus, Open-Loop Transfer Function, Poles of the Control Ratio, Applications of the Magnitude and Angle Condition.

Frequency Response: Correlation of the Sinusoidal, and Time Responses, Frequency Response Curves, Bode Plots, Frequency Transfer Function Relationship, Nyquist's Criterion, Definitions of Phase Margin and their Relation to Stability.

Root Locus Compensation Design: Introduction to Design, Transient Response Dominant Complex Poles, Additional Significant Poles, Ideal Integral Cascade Compensation (PI Controller), Ideal Derivative Cascade Compensation (FD Controller), FID Controller, Introduction to Feedback Compensation.

Introduction Digital Control Systems: Introduction, Sampling, Ideal Sampling Z-Transform Theorems, Synthesis in the Z-Domain (Direct Method), The Inverse Z-Transform, Zero-Order Hold, Analog Controller Design, Basics of Digital Control, Representation of Digital Control Systems in S-Plane and Z-Plane, Interpretation of Pole-Zero Maps in Z-Plane, Frequency-Folding Effects, Digital Design by Emulation.

14.65.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand and apply methods to model physical systems and evaluate the solution of the representative differential equations.	PO1, PO2	C1, C2, P1, P2	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO2	Understand and implement methods for simplification of complex systems to find its transfer function.	PO1, PO3	C1, C2, C4, P1, P3	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO3	Analyze time domain and frequency domain response of systems and investigate ways of improving system performance.	PO2, PO3	C1, C2, C4, P1, P4	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO4	Construct graphs to identify system stability and design subsystems to improve system responses.	PO3	C1, C2, C3, C5, P1, P4	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO5	Understand the basic principles of digital control systems.	PO1	C1, P1, P2	Lectures, Discussions, Handout	Assignment, Presentation, Class work

14.65.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓						✓	✓	✓	✓				✓	✓			

14.65.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction, control system terminology, design approaches of controller, classical examples, definitions of control system terminologies, control system and response, stability, computer controlled systems, primary objectives of control system analysis and design, steps involved in the design of a control system.	CO1, C02
2	3-4	Introduction to writing system equations, electric circuits and components, state concepts, state, state vector, state space, state trajectory, energy storage elements, example – series RLC circuit, state equations and examples, transfer function of block diagrams.	CO1, CO2
3	5-6	Mechanical translation systems, multiple-element mechanical translation system, mechanical rotational systems, multiple-element mechanical rotational system, effective moment of inertia and damping of a gear train.	CO1
4	7-8	Introduction to solution of differential equations, standard inputs to control systems, steady-state response: sinusoidal input, steady-state response: polynomial input, step-function input, ramp-function input, parabolic-function input, transient response: classical method, complex roots, damping ratio and un-damped natural frequency, definition of time constant.	CO1, CO3
5	9	Example of second order mechanical system, introduction to Laplace transform, definition of Laplace transform, derivation of Laplace transforms of simple functions, Laplace transform theorems, inverse Laplace transform, application of the Laplace transform to differential equations.	CO1
5-6	10-11	Second order transients, response characteristics, time response specifications, CAD accuracy checks, under-damped second order systems, evaluation of T_p, %OS, T_s, T_r from transfer function, graphical interpretation of the pole plot and response.	CO1, CO3
6	12	State-variable equations, state transition matrix and its properties, characteristic values, evaluating the state transition matrix, example of finding STM.	CO1
7	13	Block diagrams, cascade form, parallel form, feedback form, moving blocks to create familiar forms, block diagram	CO2

		reduction via familiar forms, reduction of block diagrams, block diagram reduction by moving blocks.	
7-8	14-15	Position control system, signal flow graphs, flow-graph definitions, flow-graph algebra, Mason's gain rule, transfer function via Mason's rule, simulation diagrams, signal-flow graphs of state equations.	CO2
8	16	Introduction to control system characteristics, Routh-Hurwitz stability criterion, Routh-Hurwitz criterion: special cases, pole distribution via Routh table, stability in state space.	CO3
9	17-18	Mathematical and physical forms, steady-state errors: definition and test inputs, evaluating steady-state errors, sources of steady-state error, steady-state error for unity feedback systems, steady-state error in terms of G(s), step input, ramp input, and parabolic input, steady-state errors for systems with no integrations example, steady-state errors for systems with one integrations example, static error constants and system type, static error constants, steady-state error via static error constants example, system type, steady-state error specifications, interpreting the steady-state error specification, steady-state error for disturbances, non-unity feedback system, steady-state error for non-unity feedback systems, problems and solutions, steady-state error and response characteristic tables.	CO3
10	19-20	Introduction to root locus, a typical feedback control system, plotting roots of a characteristic equation, effect of gain K on ς and ω_n, qualitative analysis of the root locus. The control system problem, vector representation of complex numbers, evaluation of a complex function via vectors, open-loop transfer function, poles of the control ratio C(s)/R(s), application of the magnitude and angle conditions, example.	CO1, CO3
11	21-22	Rules of graphical sketching of root locus, number of the branches of the locus, real-axis locus, locus end points, asymptotes of locus as s approaches infinity, real-axis intercept of the asymptotes, breakaway point on the real axis, complex pole (or zero): angle of departure and of arrival, imaginary axis crossing point.	CO1, CO4
12	23	Introduction to root locus compensation design, improving transient response, improving steady-state error, configurations, compensators, improving steady-state error via cascade compensation, introduction to design, transient response – dominant complex poles, additional significant poles, reshaping the root locus, ideal integral cascade compensation (PI controller), Ideal derivative	CO1, CO4

		cascade compensation (PD controller), PID controller, feedback compensation.	
12	24	Introduction to frequency response, the concept of frequency response, correlation of the sinusoidal and time response, frequency response curves, Bode plots (logarithmic plots), some basic definitions of logarithmic terms, general frequency – transfer function relationships, basic types of factors (constants, $j\omega$ factors, $1 + j\omega T$ factors, and quadratic factors).	CO3, CO4
13	25	Introduction to Nyquist criterion, derivation of the Nyquist criterion, applying the Nyquist criterion to determine stability, sketching the Nyquist diagram, Nyquist diagram for open-loop function with poles on contour example, stability via the Nyquist diagram, range of gain for stability via Nyquist criterion, stability via mapping positive jω-axis example, gain margin and phase margin via the Nyquist diagam, finding gain and phase margins, defintions of phase margin and gain margin and their relation to stability, relative stability.	CO3, CO4
13-14	26-28	Introduction to digital control systems, digital-to-analog conversion, analog-to-digital conversion, modeling the digital computer, modeling the sampler, sampling, ideal sampling, modeling the zero-order hold, z-transform, z-transform of a time function, z-transform theorems, synthesis in the z domain (direct method), z-plane stability, system stability, system analysis, the inverse z-transform, inverse z-transform via partial fraction expansion, inverse z-transform via the power series method, zero-order hold, mapping from the s-plane into z-plane, digital system stability via the z-plane, folding and aliasing. Digital design by emulation.	CO5

14.65.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%

Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.65.8 Text Books and Reference Books

1) Control Systems Engineering, 6th Edition, Norman S. Nise, Wiley.

2) Modern Control Engineering, 5th Edition, Katsuhiko Ogata, Pearson.

3) Linear Control System Analysis and Design, John Joachim D'Azzoand Constantine H. Houpis, McGraw-Hill.

14.66 Control Engineering Laboratory

14.66.1 Introduction of the Course

Course Code and Title: 0714-EEE-4202: Control Engineering Laboratory.

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week.

Rationale of the Course: In order to strengthen the theoretical understanding of Control Engineering, it is necessary to have knowledge and experience of implementing different aspects of Control Engineering practically, like firsthand experience. Therefore, the Control Engineering lab course is an integrated part of the relevant theoretical course. This course is designed to equip students with some skills of designing and implementing control systems, both using hardware and simulation software.

Prerequisites (if any): 0713-EEE-1101: Electrical Circuit Analysis, 0541-MAT-1105: Differential and Integral Calculus.

14.66.2 Course Objectives

The Control Engineering Lab course is designed to give students the ability to implement different control systems and analyze those with the aim of improving the performance of the control system.

The students are expected to

1) Design and implement a speed control system using discrete components.

2) Evaluate transfer function and system response.

3) Simulate and study time domain response of a system.

4) Simulate and study frequency domain response of a system.

14.66.3 Course Content

Experiments in relevance with the 0714-EEE-4201: Control Engineering course.

Projects related to 0714-EEE-4201: Control Engineering course contents to achieve specific program outcomes.

14.66.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and	Delivery Methods	Assessment Tools

			Taxonomy Levels	and Activities	
CO1	Design and construct an electronic control system.	PO3	C1, C3, C6, P1	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO2	Evaluate the transfer function of different systems.	PO2	C1, C5, P1	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO3	Analyze the time-domain and frequency-domain responses of different systems and identify the performance parameters.	PO1, PO2	C1, C2, C4, P1, P2	Lectures, Discussions, Handout	Assignment, Presentation, Class work
CO4	Implement the state-space model of a system.	PO3	C1, C3, P1	Lectures, Discussions, Handout	Assignment, Presentation, Class work

14.66.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓						✓							✓				

14.66.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1-3	Experiment	Design and implementation of a circuit to drive stepper motor using ICs and discrete components.	CO1
4-5	Experiment	Design and implementation of an LED brightness control circuit using Arduino UNO board.	CO1
6-7	Experiment	Design and implementation of circuit to drive a stepper motor using and Arduino UNO board.	CO1
8	Experiment	Find overall transfer functions of the systems given in block diagram. Also find the poles and zeros of the overall transfer function.	CO2

9	Experiment	Obtain step response of a unity feedback system for a given forward path transfer function and find ς, ω_n, T_s, T_p, T_r and %OS.	CO3
10	Experiment	A plant to be controlled is described by a given transfer function. Obtain the root locus plot.	CO3
11	Experiment	Obtain Bode plot for a unity feedback system with a given G(s) for different values of K. Also obtain gain margin, phase margin, gain crossover frequency and phase crossover frequency.	CO3
12	Experiment	The open-loop transfer function G(s) of a unity-feedback control system is given. Draw a Nyquist plot of G(s). Also determine the stability of the system.	CO3
13	Experiment	Determine the transfer function and poles of the system represented in state space as given.	CO4
14	Experiment	Show the effect of addition of (a) a PD and (b) a PI controller on the system performance of a unity feedback system with given forward path transfer function. Also find the transient response for a PID controller.	CO2, CO3

14.66.7 Assessment Pattern/ Strategy

Assessment will be based on the successful execution of assembly language programs, correct interfacing and operation of peripherals, and the completion of comprehensive projects involving microprocessor-based systems.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.66.8 Text Books and Reference Books

1) Handout.

14.67 Quantum Mechanics

14.67.1 Introduction of the Course

Course Code and Title: 0714-EEE-4231: Quantum Mechanics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the foundational principles and advanced concepts of quantum mechanics, which are essential for grasping the behavior of physical systems at the microscopic scale. By exploring into the mathematical formalisms, symmetries, and conservation laws, students will gain the skills necessary to analyze and solve complex quantum mechanical problems.

Prerequisites (if any): 0541-MAT-1105: Differential and Integral Calculus, 0533-PHY-1201: Modern Physics, 0533-PHY-1203: Optics, 0542-STA-2207: Probability and Statistics.

14.67.2 Course Objectives

The students are expected to

1) Understand and apply the principles of operator algebra in quantum mechanics.

2) Grasp the postulates of quantum mechanics and their physical interpretation.

3) Investigate the properties and behaviors of identical particles, including bosons and fermions.

4) Comprehend symmetries and conservation laws in quantum mechanics.

5) Develop a thorough understanding of the Spin-$\frac{1}{2}$ system and two-level systems (TLS).

14.67.3 Course Content

Operator Algebra in Quantum Mechanics: Dirac Bras and Kets, Inner Product, Linear Operator and its Adjoint, Hermitian Conjugation, Orthonormal Basis and Operator Representation, Matrix Representation of Bras, Kets and Operators, Hermitian and Unitary Operators and their Eigenvectors and Eigenvalues, Complete Set of Commuting Observables, Commutation Relation, Unitary Evolution and Transformation, Parity Operator.

Postulates, Interpretations and Implications: Postulates and its Physical Interpretations in Quantum Mechanics, Measurement Process, Time Evolution of States, Conservation of Probabilities, Constant of Motion, Stationary States and Energy Eigenstates.

Different Representations in QM: Position Space Representation, Momentum Space Representation, Schrodinger Picture Representation, Heisenberg Picture Representation, Interaction Picture Representation, Path Integral Representation of Quantum Mechanics.

Quantum Harmonic Oscillator: Why Study Harmonic Oscillator, Review of Classical Harmonic Oscillator, Quantization of Harmonic Oscillator using Operator Algebra, Creation, Annihilation, Ladder and Number Operators.

Identical Particles: Identical Particles, Scattering of Identical Particles, Two-Particle Systems, Bosons and Fermions, Exchange Energy, The Slater Determinant.

Symmetries and Conservation Laws: Time translation Invariance and Conservation of Energy, Space Translation Invariance and Momentum Conservation, Rotational Invariance and Angular Momentum Conservation, Parity Conservation and Selection.

Spin-$\frac{1}{2}$ System: Mathematical Representation of Spin-$\frac{1}{2}$. Commutation Algebra of Spin Operators, Pauli Matrices, The Bloch Sphere, Wave function with Spin, Spinor Representation, The Pauli Equation.

Two Level System (TLS): General Model for TLS, Hilbert Space, Basis and Eigenstates of TLS, Effect of Coupling on Eigenstates and Eigenvalues, The Rabi Oscillation between Unperturbed TLS.

14.67.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Apply the mathematical formalism of operator algebra to solve quantum mechanical problems	PO1, PO2, PO3	C3	Lectures Handouts Exercise	Incourse Final Exam
CO2	Analyze and interpret the postulates of quantum mechanics, focusing on their physical implications	PO1, PO2, PO4	C4	Lectures Handouts Discussions	Assignment Final Exam
CO3	Investigate the behaviors and properties of identical particles, including the analysis of bosons and fermions	PO2, PO4	C4	Lectures Handouts Exercise Discussions	Final Exam
CO4	Comprehend and apply symmetries and conservation laws in quantum mechanics	PO1, PO2	C5	Lectures Handouts Discussions	Presentation Final Exam
CO5	Develop a thorough understanding of Spin-$\frac{1}{2}$ systems	PO1, PO2, PO5, PO12	C5	Lectures Handouts Discussions	Incourse Final Exam

	and two-level systems (TLS)				

14.67.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓					✓	✓	✓						✓	✓		✓

14.67.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Operator Algebra, Dirac Bra-Ket Notation, Hermitian Conjugation, Orthonormal Basis and Operator Representation, Matrix Representation of Operators.	CO1
2	3-4	Hermitian, Unitary, and Operators and their Eigenvectors and Eigenvalues, Complete Set of Commuting Observables, Postulates of Quantum Mechanics in Bra-Ket Notation, Unitary Evolution of Quantum Mechanical State.	CO1
3	5-6	Physical Interpretations of Quantum Mechanical Postulates, Unitary Time Evolution of Quantum Mechanical States, Concept of Probability Current, Conservation of Probability.	CO2
4	7-8	Finding out Constant of Motion, Concept of Stationary States, Eigen States, Calculation of Eigen States and Eigen Values.	CO2
5	9-10	Different Representations in QM: Position Space Representation, Momentum Space Representation, Schrodinger Picture Representation, Heisenberg Picture Representation, Interaction Picture Representation, Path Integral Representation of Quantum Mechanics.	CO2
6	11-12	Quantum Mechanics in Canonical Position Space and Momentum Space, Schrodinger Equation in Position and Momentum Space, Concept of Canonical Variables	CO2
7	13-14	Different Formulations of Quantum Mechanics: Schrodinger Formulation, Heisenberg Formulation, and Path Integral Formulation, The Interaction Picture of Quantum Mechanics.	CO2
8	15-16	The Importance of Harmonic Oscillator, Review of Classical Harmonic Oscillator, Creation, Annihilation, Ladder and Number Operators	CO1
9	17-18	Quantization of Harmonic Oscillator: Phonon, Finding out the Stationary States, Expected Values of Position, Momentum, Energy, and Phonon Number.	CO1

10	19-20	Identical and Indistinguishable Particles, Scattering of Identical Particles, Identical Particles Under Exchange, Symmetry of Wavefunction Under Exchange, Slater Determinant.	CO3
11	21-22	Symmetries and Conservation Laws: Time translation Invariance and Conservation of Energy, Space Translation Invariance and Momentum Conservation, Rotational Invariance and Angular Momentum Conservation, Parity Conservation and Selection.	CO4
12	23-24	Mathematical Representation of Spin-1/2, Commutation Algebra of Spin Operators, Pauli Matrices, The Bloch Sphere,	CO5
13	25-26	Wave function with Spin, Spinor Representation, The Pauli Equation, General Model for Two Level System: Hilbert Space, Basis and Eigenstates.	CO5
14	27-28	Effect of Coupling on Eigenstates and Eigenvalues in Two Level System, The Rabi Oscillation between Stationary Sates of Two-Level System.	CO5

14.67.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.67.8 Text Books and Reference Books

1) Quantum Mechanics, Vol. 1, 1st Edition, Claude Cohen-Tannoudji, Bernard Diu and Frank Laloe, Wiley.

2) Introduction to Quantum Mechanics, 3rd Edition, David J. Griffiths and Darrell F. Schroeter, Cambridge University Press.

3) Quantum Mechanics for Scientists and Engineers, 1st Edition, David A. B. Miller, Cambridge University Press.

4) Principles of Quantum Mechanics, 2nd Edition, R. Shankar, Plenum Press.

5) Quantum Mechanics, 4th Edition, Walter Greiner, Springer.

14.68 Nanoelectronics

14.68.1 Introduction of the Course

Course Code and Title: 0714-EEE-4233: Nanoelectronics.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The course is designed to meet the increasing demand for expertise in the field of nanotechnology, equipping students with a comprehensive study of electronic phenomena at the nanoscale level. The course focuses on revising the traditional model of electronics due to nanoscale dimensions of devices and introducing the significance of quantum mechanics in such devices. The course also covers topics like ballistic and diffusion conductance, quantum capacitance, transmission theory of nanoscale MOSFETs, addressing the distinctive characteristics and limitations presented by nanoelectronics.

Prerequisites (if any): 0533-PHY-1201: Modern Physics, 0531-CHE-1207: Chemistry, 0714-EEE-2105: Solid State Physics, 0714-EEE-3109: Electronic Devices, 0714-EEE-3205: Materials Science, 0714-EEE-3207: Optoelectronics and Photonics.

14.68.2 Course Objectives

The students are expected to

1) Develop a foundational understanding of nanoelectronic principles.

2) Comprehend various types of electron conductance, emphasizing their impact on the behavior and performance of semiconductor devices operating at the nanoscale.

3) Explore the quantum transport phenomena in nanoscale MOSFETs, considering the limits and challenges faced by these devices.

14.68.3 Course Content

The New Perspective: Introduction, Two Key Concepts, Why Electronics Flow, Conductance Formula, Ballistic (B) Conductance, Diffusive (D) Conductance, Connecting B to D, Angular Averaging, Drude Formula.

Energy Band Mode: E(p) or E(k) Relations, Counting States, Density of States, Number of Modes, Electron Density (n), Conductivity vs Electron Density (n), Quantum Capacitance.

What and Where is the Voltage: A New Boundary Condition, Quasi-Fermi Levels (QFL’s), Current from QFL’s, Landauer Formulas, What a Probe Measures, Electrostatic Potential, Boltzmann Equation, Spin voltages.

Heat, Electricity, Second Law and Information: Seebeck Coefficient, Heat Current, One-level Device, Second Law Entropy, Law of Equilibrium, Shannon Entropy, Fuel Value of Information.

Ballistic Nanotransistors: MOSFET Device Metrics, Traditional IV Theory, The Virtual Source Model, Depletion Approximation, 2D MOS Electrostatics Mobile Charge: Bulk MOS and Extremely Thin Silicon-on-Insulator MOS (ETSOI), The Landaur Approach, The

Ballistic MOSFET, The Velocity at the Virtual Source, Revisiting the Virtual Source Model.

Transmission Theory of Nanoscale MOSFETs: Carrier Scattering and Transmission, Mean Free Path and Diffusion Coefficient, Transmission Theory of MOSFET, Semi-Classical Transport in Nanoscale MOSFETs, Quantum Transport, Connection to Virtual Source Model, Analysis of Experiments, Limits of MOSFETs.

14.68.4 Course Outcomes (COs)

CO No.	CO Statement	Corres-ponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate a comprehensive understanding of the principles of nanoelectronics, encompassing important concepts like carrier conductance, formation of energy bands and quantum capacitance	PO1	C1	Lectures Discussions Handouts	Incourse Final Exam
CO2	Apply the principles of energy band relations, density of states and quantum mechanics to analyze electron behavior at the nanoscale	PO1, PO2	C3, C4	Lectures Discussions Handouts	Assignment Final Exam
CO3	Develop skills in employing depletion approximation methods to model the behavior of MOSFETs, especially in regions where the channel is depleted of carriers	PO4	C3, C4	Lectures Discussions Handouts	Assignment Final Exam
CO4	Comprehend the electrostatics of two-dimensional (2D) MOS structures and the principles governing electronic transport in MOSFETs	PO1	C1, C2	Lectures Discussions Handouts	Incourse Final Exam

14.68.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓					✓								✓	✓		✓

14.68.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Nanoelectronics, Flow of Electrons, Conductance Formula, Ballistic (B) Conductance, Diffusive (D) Conductance.	CO1
2	3-4	Connecting B to D, Angular Averaging, Drude Formula, E(p) or E(k) Relations, Counting States, Density of States.	CO2
3	5-6	Number of Modes, Electron Density (n), Conductivity vs Electron Density (n), Quantum Capacitance.	CO1
4	7-8	New Boundary Conditions, Quasi-Fermi Levels (QFL's), Current from QFL's.	CO2
5	9-10	Landauer Formulas, Probe Measures, Electrostatic Potential, Boltzmann Equation, Spin voltages.	CO3
6	11-12	Introduction to the Concepts of Heat and Electricity, Seebeck Coefficient, Heat Current, One-level Device.	CO2
7	13-14	Second Law Entropy, Law of Equilibrium, Shannon Entropy, Fuel Value of Information, MOSFET Device Metrics.	CO2
8	15-16	Traditional IV Theory, The Virtual Source Model, Depletion Approximation.	CO3
9	17-18	2D MOS Electrostatics Mobile Charge: Bulk MOS and Extremely Thin Silicon-on-Insulator MOS (ETSOI).	CO4
10	19-20	The Landaur Approach, The Ballistic MOSFET.	CO4
11	21-22	The Velocity at the Virtual Source, Revisiting the Virtual Source Model.	CO4
12	23-24	Carrier Scattering and Transmission, Mean Free Path and Diffusion Coefficient, Transmission Theory of MOSFET.	CO4
13	25-26	Semi-Classical Transport in Nanoscale MOSFETs, Quantum Transport.	CO4
14	27-28	Connection to Virtual Source Model, Analysis of Experiments, Limits of MOSFETs.	CO4

14.68.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: Minimum 1 Assignment will be given, which has to be submitted at the end of the semester.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.68.8 Text Books and Reference Books

1) Lessons from Nanoelectronics: A New Perspective on Transport, Supriyo Datta, World Scientific Pub.

2) Lessons from Nanoelectronics: Fundamentals of Nanotransistor, Mark Lundstorm, World Scientific Pub.

14.69 Mobile Cellular Communication

14.69.1 Introduction of the Course

Course Code and Title: 0714-EEE-4241: Mobile Cellular Communication.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of mobile cellular communication principles, technologies, and systems. By exploring the evolution of mobile radio communication, the fundamentals of cellular systems, and advanced technologies like 3GPP LTE and 5G, students will gain the knowledge and skills necessary to design, implement, and manage contemporary mobile communication networks.

Prerequisites (if any): 0714-EEE-3105: Communication Systems, 0714-EEE-3209: Communication Theory.

14.69.2 Course Objectives

The students are expected to

1) Understand the fundamental principles, evolution, and specifications of mobile radio communication systems.

2) Master the core concepts of cellular mobile systems, including frequency reuse, handoff strategies, and capacity calculations.

3) Examine and model mobile radio propagation characteristics, including multipath propagation, fading, and Doppler shift.

4) Manage and optimize frequency management, channel assignment, and handoff mechanisms to enhance system performance.

5) Explore and evaluate advanced digital cellular systems, mobile data networks, and emerging technologies like LTE, LTE Advanced, and 5G.

14.69.3 Course Content

Introduction: Evolution and Concept of Mobile Radio Communication, Concept of Cellular Mobile System, Generations of Cellular Mobile Systems, Specifications of Analog Cellular Systems.

Cellular Mobile System Fundamentals: Frequency Reuse and Frequency Planning, Co-Channel Interference, Hand Off, Traffic Intensity, Grade of Service (GoS), Capacity Calculation, Trunking Efficiency, Cell Splitting, Micro Cell Zone.

Mobile Radio Propagation: Propagation Characteristics, Multipath Propagation, Multipath Fading, Delay Spread, Doppler Shift, Models for Radio Propagation.

Frequency Management and Channel Assignment: Fundamentals, Spectrum Utilization, Fundamentals of Channel Assignment, Fixed Channel Assignment, Non-Fixed Channel Assignment, Traffic and Channel Assignment, Sectorization.

Handoffs and Dropped Calls: Reasons and Types, Forced Handoffs, Mobile Assisted Handoffs and Dropped Call Rate.

Diversity Techniques: Concept of Diversity Branch and Signal Paths, Carrier to Noise and Carrier to Interference Ratio Performance.

Digital Cellular Systems: Concept of TDMA and CDMA; IS-54/136 (NA- TDMA), GSM – GSM System Architecture, Protocol Layers, GSM Air Interface Specification, IS-95, CDMA-2000, W-CDMA, Mobile Cellular Data Networks: GPRS/EDGE, IMT-2000, UMTS, HSDPA/HSUPA.

3GPP, LONG TERM EVOLUTION (LTE) and LTE Advanced: Key- Parameters, Frequency Range, FDD, TDD, Modulation Schemes, Multiple Access, MIMO Technology, Data-Rates, Channel Mapping, Types of Resource Allocation.

5G Technology: High Capacity Requirements, Expanding Connectivity Needs, Multi-Connectivity Across Bands and Technologies, Diverse Spectrum Types and Bands, New Unified Air Interface, Triangle Diagram, Multi-Antenna Technology (Beam forming).

14.69.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate an understanding of the fundamental principles, evolution, and specifications of mobile radio communication systems	PO1	C1, C2	Lectures Discussions Handouts	Presentation Final Exam

CO2	Apply the core concepts of cellular mobile systems, including frequency reuse, handoff strategies, and capacity calculations, to solve problems in cellular mobile systems	PO1, PO2, PO5	C3, P4	Lectures Exercise Handouts	Assignment Incourse Final Exam
CO3	Analyze and model mobile radio propagation characteristics, including multipath propagation, fading, and Doppler shift, using appropriate techniques and tools	PO2, PO4, PO5	C4, C5, P5	Lectures Exercise Handouts	Assignment Final Exam
CO4	Design and optimize frequency management, channel assignment, and handoff mechanisms to enhance cellular network performance	PO1, PO3	C5, P6	Lectures Discussions Handouts	Incourse Final Exam
CO5	Evaluate and compare architecture, protocols, and performance of advanced digital cellular systems and emerging technologies	PO1, PO5, PO7	C6, A4	Lectures Discussions Handouts	Presentation Final Exam

14.69.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓		✓	✓	✓	✓			✓		✓			✓	✓	✓		✓	✓	

14.69.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction: Evolution and Concept of Mobile Radio Communication, Generations of Cellular Mobile Systems, Specifications of Analog Cellular Systems.	CO1
2-3	3-6	Cellular Mobile System Fundamentals: Frequency Reuse and Frequency Planning, Co-Channel Interference, Handoff Strategies, Traffic Intensity, Grade of Service (GoS), Capacity Calculation, Trunking Efficiency, Cell Splitting, Micro Cell Zone.	CO2
4	7-8	Mobile Radio Propagation: Propagation Characteristics, Multipath Propagation, Multipath Fading, Delay Spread, Doppler Shift.	CO3
5	9-10	Models for Radio Propagation: Mathematical and Empirical Models for Mobile Radio Propagation.	CO3
6	11-12	Frequency Management and Channel Assignment: Fundamentals of Spectrum Utilization, Fixed and Non-Fixed Channel Assignment, Traffic and Channel Assignment.	CO4
7	13-14	Handoffs and Dropped Calls: Reasons and Types, Forced Handoffs, Mobile-Assisted Handoffs, Dropped Call Rate Analysis.	CO4
8	15-16	Diversity Techniques: Concept of Diversity Branch and Signal Paths, Carrier-to-Noise and Carrier-to-Interference Ratio Performance.	CO3, CO4
9-10	17-20	Digital Cellular Systems: TDMA and CDMA, Overview of IS-54/136 (NA-TDMA), GSM Architecture and Protocol Layers, GSM Air Interface Specification, IS-95, CDMA-2000, W-CDMA; Mobile Cellular Data Networks – GPRS/EDGE, IMT-2000, UMTS, HSDPA/HSUPA.	CO5
11-12	21-24	3GPP, LTE, and LTE Advanced: Key Parameters, Frequency Range, FDD, TDD, Modulation Schemes, MIMO Technology, Data Rates, Channel Mapping, Types of Resource Allocation, Multiple Access Techniques.	CO5
13-14	25-28	5G Technology: High Capacity Requirements, Expanding Connectivity Needs, Multi-Connectivity Across Bands and Technologies, New Unified Air Interface, Triangle Diagram,	CO5

		Multi-Antenna Technology (Beam forming), Diverse Spectrum Types and Bands.	

14.69.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.69.8 Text Books and Reference Books

1) Signal Processing and Detection, John Cioffi.

2) Modulation and Coding for Wireless Communications, Burr A, Prentice Hall.

3) Digital Communications Fundamentals and Applications, Sklar B, Prentice Hall.

4) Wireless Communications, Andre Goldsmith, Cambridge University Press.

5) WCDMA for UMTS: HSPA Evolution and LTE, Harri Holma and Antti Toskala, John Wiley & Sons.

6) GSM Switching, Services and Protocols, J. Eberspacher and H. Vogel, Wiley.

7) GSM - Evolution towards 3rd Generation Systems, Z. Zvonar, P. Jung and K. Kammerlander, Kluwer.

8) MIMO Wireless Networks: Channels, Techniques and Standards for Multi-Antenna, Multi-User and Multi-Cell Systems, B. Clerckx and C. Oestges, Academic Press (Elsevier).

9) Wireless Communications: Principles and Practice, 2nd Edition, Theodore S. Rappaport, Prentice Hall.

10) Fundamentals of Wireless Communication, 1st Edition, David Tse and Pramod Viswanath, Cambridge University Press.

11) Mobile Wireless Communications, 1st Edition, Mischa Schwartz, Cambridge University Press.

12) Fundamentals of Mobile Data Networks, 1st Edition, Guowang Miao, Jens Zander, Ki Won Sung and Ben Slimane, Cambridge University Press.

13) Introduction to Digital Mobile Communication, 2nd Edition, Yoshihiko Akaiwa, Wiley.

14) Wireless Communications & Networks, 2nd Edition, William Stallings, Pearson.

15) 5G Mobile and Wireless Communications Technology, 1st Edition, Afif Osseiran, Jose F. Monserrat, Patrick Marsch, Mischa Dohler and Takehiro Nakamura, Cambridge University Press.

16) An Introduction to LTE, 2nd Edition, Christopher Cox, Wiley.

14.70 Microwave and Satellite Communication

14.70.1 Introduction of the Course

Course Code and Title: 0714-EEE-4243: Microwave and Satellite Communication.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course emphasizes the critical role of microwave and satellite technologies in modern communication systems. It aims to provide students with a comprehensive foundation in the principles of microwave generation, circuit design, and radar systems, enabling them to effectively analyze and design complex communication systems. By exploring both the theoretical and practical aspects of microwave and satellite communication, students will be equipped to tackle real-world engineering challenges and contribute to advancements in the field.

Prerequisites (if any): 0714-EEE-3101: Electromagnetic Theory and Antenna, 0714-EEE-3209: Communication Theory.

14.70.2 Course Objectives

The students are expected to

1) Develop a solid understanding of microwave generation devices and their applications in high-frequency communication systems.

2) Gain proficiency in analyzing and designing microwave circuits using advanced network analysis techniques.

3) Explore and understand the radar and satellite communication systems, and their technological advancements.

14.70.3 Course Content

Microwave Generation: Klystron, Reflex Klystron, Magnetron and Microwave Semiconductor Devices, Microwave Components, Microwave Measurements: Power, Frequency, and Wavelength.

Microwave Circuit Design: Low Frequency Parameters, S-, Y-, Z-Parameter, ABCD Parameters, Transmission Matrix, Passive Circuit Design, Mixer Design, Microwave Control Circuit Design, Wireless Microwave Systems, Noise in Microwave Circuits, Microwave IC (HMICs, MMICs).

Microwave Engineering for Wireless System: Microwave Networks, Active Networks, Microwave Link, Rectifier and Detector Design, Transmitting and Receiving Equipment.

Introduction to Radar: Applications of Radar, Radar Frequencies, Basic Principles, Radar Equation, Minimum Detectable Signal, Factors Influencing Maximum Range, Effect of Noise, Doppler Effect, Radar Cross-Section of Targets, PRF and Range Ambiguities, Transmitter Power, System Losses.

Different Types of Radar: Basic Pulsed Radar System, Modulators, Receivers, Bandwidth Requirements, Factors Governing Pulse Characteristics, Duplexer, Moving Target Indicator (MTI), MTI Radar, Limitations to the Performance of MTI Radar, Non-Coherent MTI Radar, CW radar, FM CW Radar, Multiple Frequency CW Radar, Blind Speeds, Staggered PRF, Tracking Radar Systems (Sequential Lobing, Conical Scan), Radar Antennas, Radar Displays.

Satellite Communication: Introduction, Geo-Synchronous and Geo-Stationary Satellites, Kepler's Laws, Locating the Satellite with Respect to the Earth, Sub- Satellite Point, Look Angles, Mechanics of Launching a Synchronous Satellite, Orbital Effects.

Satellite Sub-Systems: Attitude Determination and Control Sub-systems, Mechanical Sub-system, Telemetry, Tracking and Command Control System, Power Supply System, Space Craft Antennas, Multiple Access Techniques, Earth Station Equipment, Tracking Systems.

Satellite Link Design: Basic Transmission Theory, Transmission Path, Path Loss, System Noise Temperature and G/T Ratio, Design of Down Link and Uplink, Impact of G/T-Saturation Flux Density (SFD)-Effective Isotropic Radiated Power (EIRF) on System Design.

Miscellaneous: Satellite Communication for Internet (VSAT), Global Navigation Satellite System (GNSS) i.e., GPS/GLONASS/Galileo/Beidou, Satellite Television (DBS Satellite), Geographic Information System (GIS) and Remote Sensing, CubeSat, NanoSat.

14.70.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the working principles and operation of microwave generation devices	PO1, PO5	C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Analyze and design microwave circuits using S-parameters, Y-parameters, and other network analysis techniques	PO2, PO3, PO5	C4	Lectures Discussions Exercise	Assignment Final Exam
CO3	Evaluate the performance of radar systems by understanding radar fundamentals and	PO2, PO4	C6	Lectures Discussions	Incourse Final Exam

	signal processing techniques				
CO4	Design satellite communication links and understanding the impact of various parameters on system performance	PO3, PO5, PO7	C5	Lectures Discussions Exercise	Class work Final Exam

14.70.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
		✓	✓	✓	✓			✓		✓			✓	✓	✓	✓	✓	✓	

14.70.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Microwave and Satellite Communication Overview of Microwave Generation Devices	---
2	3-4	Klystron, Reflex Klystron: Working Principles and Applications Magnetron: Working Principles and Applications	CO1
3	5-6	Microwave Semiconductor Devices: Diodes, Transistors Microwave Components: Circulators, Isolators, Waveguides Microwave Measurements: Power, Frequency, Wavelength	CO1
4	7-8	Introduction to Microwave Circuit Design, Low-Frequency Parameters S-Parameters: Theory and Applications, Y-Parameters and Z-Parameters, ABCD Parameters, Transmission Matrix, Passive Circuit Design	CO2
5-6	9-11	Mixer Design, Microwave Control Circuit Design Wireless Microwave Systems, Noise in Microwave Circuits Microwave Integrated Circuits (HMICs, MMICs) Microwave Networks, Active Networks, Microwave Link Design: Transmitting and Receiving Equipment	CO2
6-7	12-14	Introduction to Radar Systems: Basic Principles, Radar Frequencies, Radar Equation, Minimum Detectable Signal, Noise in Radar Systems	CO3
8-9	15-18	Doppler Effect, Radar Cross-Section of Targets, PRF, Range Ambiguities, System Losses, Transmitter Power	CO3

		Types of Radar: Pulsed Radar, CW Radar, FM-CW Radar MTI Radar, Non-Coherent MTI Radar, Blind Speeds, Staggered PRF	
10	19-20	Tracking Radar Systems: Sequential Lobing, Conical Scan Radar Antennas, Radar Displays, Applications of Radar	CO3
11-13	21-26	Introduction to Satellite Communication: Geo-Synchronous, Geo-Stationary Satellites Satellite Sub-Systems: Attitude Determination, Power Supply, Tracking Systems Satellite Link Design: Uplink and Downlink Design	CO4
14	27-28	Miscellaneous: GNSS, VSAT, Remote Sensing, CubeSat, NanoSat	CO4

14.70.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.70.8 Text Books and Reference Books

1) Electronic Communication Systems, G. Kennedy and B. Davis, McGraw-Hill.

2) Microwave Devices and Circuits, Samuel Y. Liao, Prentice Hall.

3) Microwave Engineering, David M. Pozar, John Wiley & Sons.

4) Introduction to Radar Systems, M.I. Skolnik, McGraw-Hill.

5) Principles of Modern Radar: Basic Principles, Mark A. Richards, James A. Scheer and William A. Holm, Scitech Publisher.

6) Radar: Principles, Technology, Applications, Byron Edde, Pearson.

7) Satellite Communications, T. Pratt & J. Allnutt, John Wiley & Sons.

8) Satellite Communication Systems, B.G. Evans, IET Series.

9) Satellite Communications, Dennis Roddy, McGraw-Hill.

14.71 Power System Operation and Control

14.71.1 Introduction of the Course

Course Code and Title: 0713-EEE-4251: Power System Operation and Control.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The concepts of Economic Load Dispatch, Unit commitment, State Estimation, Load frequency control, voltage control, and real-time control of modern power systems are required for the future research and development of modern power systems. By going through this course students will familiarize with the basic on integrated and deregulated power system with real time operation and various data acquisition devices. With the proper knowledge of this course students will know the proper management of energy system with automatic generation control for economic and continuous energy supply purposes. They will also be able to learn about power system security, SCADA system and electricity market which is becoming much important case in modern days.

Prerequisites (if any): 0713-EEE-3201: Power System I.

14.71.2 Course Objectives

The students are expected to

1) Learn the basic tools and techniques of power system operation and control.

2) Understand the methods for solving economic dispatch and generation control of a power system.

3) Acquire the knowledge of power security and electricity market in the context of power system operation.

4) Understand the process of controlled generation to meet the forecasted load demands.

5) Investigate real time operation and power system monitoring through SCADA.

6) Learn the basic concepts of various data acquisition devices, such as RTU, IED, PMU, FDR, and WAMPAC.

14.71.3 Course Content

Power System Operation: Overview of Operating Principles of Power System.

Power System Operations: State Estimation, Load Forecasting, Unit Commitment, Economic Dispatch, Optimal Power Flow.

Frequency Control: Generation and Turbine Governors, Droop, Frequency Sensitivity of Loads, Area Control Error (ACE), Automatic Generation Control (AGC) and Coordination with Unit Commitment and Economic Dispatch, Frequency Collapse and Emergency Load Shed.

Power System Security: Static and Dynamic; Security Constrained OPF.

Demand Side Control: Distribution Management System, Demand Side Management, and Smart Grid Concept.

Power System Monitoring: Real Time Operation- SCADA, Energy Management System, Various Data Acquisition Devices–Remote Terminal Unit(RTU), Intelligent Electronic

Device(IED), Phasor Measurement Unit(PMU),Frequency Disturbance Recorder(FDR), Wide Area Monitoring, Protection and Control(WAMPAC).

Electricity Market Operation: GenCos, ISO, DisCos, Bidding, Spot Market, Social Welfare, Market Clearing Price (MCP), Locational Marginal Price (LMP), Bilateral Contracts and Forward Market, Hedging.

14.71.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Discuss the basic structures of power system and apply the knowledge of power system operation to perform system state estimation and unit commitment	PO1, PO2	C1, C2	Lectures Discussions Handouts	Assignment Incourse Final Exam
CO2	Explain the significance of automatic generation control and coordination with unit commitment and optimal power flow	PO4	C1, C2	Lectures Discussions	Assignment Incourse Final Exam
CO3	Design a power system considering both security and economy. Analyze the impact of contingencies on power system operation and identify the preventive or corrective means to reduce those considering various constraints	PO3	C3, C4	Lectures Discussions Exercise	Assignment Incourse Final Exam

CO4	Discuss the basic structure of SCADA and techniques to control power flow, frequency and voltage through wide area monitoring, protection and control using various data acquisition devices	PO5	C2	Lectures Discussions	Assignment Incourse Final Exam
CO5	Identify the barriers and of requirements in implementing electricity market i.e. offering to the bulk consumers or distribution entities, the flexibility in choice of electricity supplier and availing of competitive tariff	PO4	C5	Lectures Discussions	Assignment Incourse Final Exam

14.71.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓				✓	✓	✓					✓	✓	✓		

14.71.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Power System Operation: Overview of Operating Principles of Power System, State Estimation	CO1
2	3-4	Power System Operations: Load Forecasting, Unit Commitment, Economic Dispatch, Optimal Power Flow	CO1 CO2
3	5-6	Frequency Control: Generation and Turbine Governors, Droop, Frequency, Sensitivity of Loads, Area Control Error (ACE)	CO2
4-5	7-10	Automatic Generation Control: AGC and Coordination with Unit Commitment and Economic Dispatch, Frequency	CO2

		Collapse and Emergency Load Shed	
6-7	11-14	Power: Static and Dynamic, Security Constrained OPF. Demand Side Control: Distribution Management System, Demand Side Management, and Smart Grid Concept.	CO3
8-9	15-18	Power System Monitoring: Real Time Operation- SCADA, Energy Management System, Various Data Acquisition Devices– Remote Terminal Unit (RTU)	CO4
10-11	19-22	Various Data Acquisition Devices - Intelligent Electronic Device (IED), Phasor Measurement Unit (PMU), Frequency Disturbance Recorder (FDR), Wide Area Monitoring, Protection and Control (WAMPAC)	CO4
12-13	23-26	Electricity Market Operation: GenCos, ISO, DisCos, Bidding, Spot Market, Social Welfare, Market Clearing Price (MCP)	CO5
14	27-28	Electricity Market Operation: Locational Marginal Price (LMP), Bilateral Contracts and Forward Market, Hedging	CO5

14.71.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.71.8 Text Books and Reference Books

1) Power System Stability and Control, 1stEdition, Prabha Kundur, McGrawHill.

2) Elements of Power System Analysis, William D. Stevenson, McGraw-Hill.

3) Electric Energy Systems-Analysis and Operation, 1stEdition, Antonio Gomez Exposito, Antonio J. Conejo and Claudio Canizares, CRC Press.

4) Power Generation, Operation, and Control, 3rdEdition, Allen J. Wood, Bruce F. Wollenberg, and Gerald B. Sheble, Wiley-Interscience.

5) Electric Power Engineering Handbook, Leonard L. Grigsby, CRC Press.

6) Power System Dynamics: Stability and Control, 2nd Edition, Jan Machowski, Janusz W. Bialek, and James R. Bumby, Wiley.

7) Smart Grid- Technology and Applications, Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, Wiley.

14.72 Power Plant Engineering

14.72.1 Introduction of the Course

Course Code and Title: 0713-EEE-4253: Power Plant Engineering.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The Power Plant Engineering course is essential for electrical and electronic engineering students, providing a comprehensive understanding of various power generation technologies and their operational principles. It bridges theoretical concepts with practical applications in the power industry, covering conventional thermal, nuclear, hydroelectric, and renewable energy sources. This course is crucial for future electrical engineers involved in power system design, operation, and management. It emphasizes both technical aspects and economic considerations of power generation, preparing students to address complex engineering challenges related to energy efficiency and environmental sustainability in the rapidly evolving power sector

Prerequisites (if any): 0715-MEC-2205: Fundamentals of Mechanical Engineering.

14.72.2 Course Objectives

The students are expected to

1) Develop a thorough understanding of the principles, working mechanisms, and thermodynamic cycles of various power generation systems.

2) Evaluate the efficiency, operational characteristics, and performance metrics of different power plants while considering technical, economic, and environmental factors.

3) Investigate the potential of renewable energy sources such as solar, wind, geothermal, and tidal power, along with emerging technologies like magnetohydrodynamic (MHD) power generation.

4) Examine the cost structures, load management, and environmental impact of power plants, promoting sustainable and economically viable energy production.

5) Develop problem-solving skills by applying power plant engineering principles to practical scenarios, preparing for careers in power generation, system design, and energy management.

14.72.3 Course Content

Sources of Energy: Fossil Fuel-Coal, Oil, Natural Gas, Coal Classification, Coal Composition and Analysis, Coal Properties, Oil Composition and Analysis, Combustion of Fuels.

Steam Power Plants: Thermodynamic Cycles and use of High Steam Pressure and Temperature, Superheating of Steam, Reheat Cycle, Regenerative Cycle, Binary Vapour

Cycle, Steam Generators- Economiser and Air Preheater, Condenser, Supply of Cooling Water to Condenser, Cooling Towers.

Gas Turbine Power Plants: Operation of Gas Turbine Power Plant, Open Cycle Plant, Closed Cycle Plant, Combined Gas Turbine and Steam Turbine Cycle.

Hydro Electric Plants: Selection of Site, Classification and Basic Schemes, Types of Turbines, Capacity Calculation, Pump Storage Projects.

Nuclear Power Plant: Types of Fuels, Classification of Reactors, Methods of Cooling, Moderators, Methods of Control, Safety Measures, Nuclear Reactor- Boiling Water Reactor, Pressurized Heavy Water Reactor, Fast Breeder Reactor, Cost of Nuclear Energy.

Other Power Sources: Principle of MHD Power Generation, Open Cycle MHD System and Closed Cycle MHD System, Tidal, Wind and Geothermal Power Generation, Solar Power Plant.

Power Plant Economics: Load Curves, Electric Power Generation Cost, Power Station Performance and Operation Characteristics.

14.72.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the principles, working mechanisms, and thermodynamic cycles of various power generation systems	PO1, PO2, PO5	C2, A1	Lectures Discussions	Incourse Final exams
CO2	Analyze the efficiency, environmental impact, and economic aspects of different power plants	PO3, PO7, PO11	C4	Exercise, Handouts	Incourse Final Exam
CO3	Evaluate alternative and renewable power generation methods for sustainable energy solutions	PO6, PO7, PO12	C5, A2	Case Studies, Group Work	Presentation Assignment Final Exams

14.72.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓			

14.72.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Power Plants and Energy Sources (Fossil Fuels, Renewable Energy)	CO1, CO3
2	3-4	Coal Classification, Composition, and Combustion of Fuels	CO1
3	5-6	Steam Power Plants: Thermodynamic Cycles (Rankine, Reheat, Regenerative Cycles)	CO1
4	7-8	Steam Generators, Superheating, Condensers, Cooling Towers	CO1
5	9-10	Gas Turbine Power Plants: Open Cycle, Closed Cycle, Combined Cycle	CO1
6	11-12	Hydro Electric Plants: Site Selection, Classification, Turbines	CO1, CO3
7	13-14	Nuclear Power Plants: Reactor Types, Cooling Methods, Safety Measures	CO1
8	15-16	Nuclear Power Plants: Economic Aspects and Future Prospects	CO2
9	17-18	Other Power Sources: MHD Generation, Tidal, Wind, and Geothermal Power	CO3
10	19-20	Solar Power Plants: Principles and Applications	CO3
11	21-22	Power Plant Economics: Load Curves, Costs of Electric Power Generation	CO2
12	23-24	Performance Characteristics of Power Stations	CO2
13	25-26	Environmental Impact of Different Power Generation Technologies	CO2, CO3
14	27-28	Future Trends in Sustainable and Renewable Energy Systems	CO3

14.72.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be one assignment and/or report on power plant visit.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.72.8 Text Books and Reference Books

1) Electric Power Generation, Transmission and Distribution, Leonjard L. Grigsby, CRC Press.

2) Power Station Engineering and Economy, 1st Edition, Bernhardt G.A. Skrotzki and William A. Vopat, McGraw-Hill Education.

3) Power Plant Technology, M. M. El-wakil, McGraw-Hill.

4) Power plant Engineering, P. K. Nag, Tata McGraw-Hill.

14.73 Artificial Intelligence

14.73.1 Introduction of the Course

Course Code and Title: 0714-EEE-4261: Artificial Intelligence.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: Artificial Intelligence (AI) is a field that has a long history but is still constantly and actively growing and changing. In this course, students will learn the basics of modern AI as well as some of the representative applications of AI. This course provides a thorough grounding in the principles and technologies used in modern AI including machine learning, neural networks, search algorithms, knowledge representation, probabilistic reasoning and robotics and understanding. Moreover, the course will encourage students about the numerous applications and huge possibilities in the field of AI, which continues to expand human capability beyond our imagination.

Prerequisites (if any): No prerequisite.

14.73.2 Course Objectives

The students are expected to

1) Gain fundamental knowledge of artificial intelligence, machine learning, programming language used in this field and robotics.

2) Examine the architecture and performance of intelligent agents, computing models, learning/training algorithms.

3) Explore the principles of search algorithms, logic expression, probabilistic reasoning and learning algorithms used in different models.

4) Develop proficiency in programming language used in AI applications and develop solutions to real world problems using AI and machine learning.

5) Understand optimization algorithms, knowledge representation methods, and logical inference strategies essential for AI applications.

6) Learn the applications of AI, machine learning, intelligent agents and similar computing models in real world problem solutions.

14.73.3 Course Content

Introduction to Artificial Intelligence (AI): AI Programming Language: Prolog, Environment Types, Agent Types, Agent Model, Reactive Agents, Perception: Neurons – Biological and Artificial, Perceptron Learning, Linear Reparability, Multi-Layer Networks, Problem Solving and Searching: 8-Puzzle Problem, N- Queen Problem, Robotic Arm Assembly, General Search.

Review of Un-Informed Search Strategies: Breadth First Search, Uniform Cost Search, Depth-First Search, Iterative Deepening, Bidirectional Search; Informed Search Algorithms: Breath-First Search, A* Search, Beam Search, Heuristic Searching, Memory Bounded Search (e.g., IDA*, RBFS, SMA*).

Local Searches: Hill Climbing, Simulated Annealing, Constraint Satisfaction Problems, Genetic Algorithm, Motion Planning: Motion Planning Search, Configuration, Action and Obstacle, Road Map, Game Playing: Motivation, Minimax Search, Resource Limits and Heuristic Evaluation, A-B Pruning, Stochastic Games, Partially Observable Games, Continuous, Embodied Games.

Neural Networks: Multi-Layer Neural Networks, Backpropagation, Variations on Backprop, Cross Entropy, Weight Decay, Momentum, Training Tips, Applications ALVINN, TD-Gammon.

Machine Learning: Supervised Learning, Decision Trees, Reinforcement Learning, Exploration vs. Exploitation, Q-Learning, Temporal Difference Learning, General Concepts of Knowledge, Knowledge Representation, Frame Problem, Representing Time, Events and Actions, Utility and MEU, Value of Information, Decision Networks, Value Iteration Algorithm, Partially Observable Markov Decision Process, Introduction to Game Theory.

Logical Agent: Knowledge-Based Agents, Logic in General- Models and Entailment, Propositional (Boolean) Logic, Equivalence, Validity, Satisfiability, Inference Rules and Theorem Proving- Forward Chaining, Backward Chaining, Resolution.

First Order Logic: Universal and Existential Quantifiers, Keeping Track of Change, Inference in First Order Logic Planning, Situation Calculus, Belief Networks, Probabilistic Reasoning, Hidden Markov Model and the Dynamic Bayesian Network, Logical Inference, Communication, Robotics.

14.73.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools

CO1	Develop a basic understanding of artificial intelligence, machine learning, programming language used in this field and robotics.	PO1, PO5	C1, P5	Lectures Discussions Handouts Exercise	Assignment Final Exam
CO2	Analyze the architecture and performance of intelligent agents, computing models, learning/training algorithms, knowledge representation and logical inference techniques.	PO2	C4, C5	Lectures Discussions Handouts Exercise	Presentation Incourse Final Exam
CO3	Understand and investigate the concept of search algorithms, optimization algorithms, logic expression, probabilistic reasoning and learning algorithms used in different models.	PO4	C2, C5, P1	Lectures Discussions Handouts Exercise	Incourse Final Exam
CO4	Acquire skills in programming language used in AI applications and develop solutions to real world problems using AI and machine learning.	PO2, PO3	C3, C6	Lectures Discussions Handouts Exercise	Presentation Assignment Final Exam
CO5	Learn the applications of AI, machine learning,	PO3, PO5	C3, P2, P5	Lectures Discussions Handouts	Assignment Final Exam

	intelligent agents and similar computing models in real world problem solutions.			Exercise	

14.73.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓

14.73.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to Artificial Intelligence (AI): AI Programming Language: Prolog, Environment Types, Agent Types, Agent Model, Reactive Agents	CO1, CO4
2	3-4	Perception: Neurons – Biological and Artificial, Perceptron Learning, Linear Reparability, Multi-Layer Networks, Neural Networks: Multi-Layer Neural Networks, Backpropagation algorithm	CO1, CO2
3	5-6	Cross Entropy, Weight Decay, Momentum, Training Tips, Applications ALVINN, TD-Gammon, Problem Solving and Searching: 8-Puzzle Problem, N- Queen Problem	CO2
4	7-8	General Search, Review of Un-Informed Search Strategies: Breadth First Search, Uniform Cost Search, Depth-First Search, Iterative Deepening, Bidirectional Search;	CO2, CO3
5	9-10	Informed Search Algorithms: Breath-First Search, A* Search, Beam Search, Heuristic Searching, Memory Bounded Search (e.g., IDA*, RBFS, SMA*).	CO3, CO4
6	11-12	Local Searches: Hill Climbing, Simulated Annealing, Constraint Satisfaction Problems, Genetic Algorithm, Motion Planning: Motion Planning Search, Configuration, Action and Obstacle, Road Map	CO3, CO4
7	13-14	Game Theory, Game Playing: Motivation, Minimax Search, Resource Limits and Heuristic Evaluation, A-B Pruning, Stochastic Games, Partially Observable Games, Continuous	CO3
8	15-16	Machine Learning: Supervised Learning, Decision Trees, Reinforcement Learning, Exploration vs. Exploitation, Q-Learning, Temporal Difference Learning,	CO2, CO3

9	17-18	General Concepts of Knowledge, Knowledge Representation, Frame Problem, Representing Time, Events and Actions, Utility and MEU, Value of Information, Decision Networks, Value Iteration Algorithm,	CO4
10	19-20	Logical Agent: Knowledge-Based Agents, Logic in General-Models and Entailment, Propositional (Boolean) Logic, Equivalence, Validity, Satisfiability, Inference Rules and Theorem	CO2, CO3
11	21-22	Proving-Forward Chaining, Backward Chaining, Resolution, First Order Logic: Universal and Existential Quantifiers	CO3, CO4
12	23-24	Inference in First Order Logic Planning, Situation Calculus, Belief Networks, Probabilistic Reasoning,	CO3, CO4
13	25-26	Partially Observable Markov Decision Process, Hidden Markov Model and the Dynamic Bayesian Network, Logical Inference,	CO4
14	27-28	Robotics and Robotic Arm Assembly, Communication	CO5

14.73.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.73.8 Text Books and Reference Books

1) Artificial Intelligence: A Modern Approach, 3rd Edition, Stuart J. Russell and Peter Norvig, Pearson.

2) Artificial Intelligence, 3rd Edition, Patrick Henry Winston, Addison-Wesley.

3) Artificial Intelligence: What Everyone Needs to Know, 1st Edition, Jerry Kaplan, Oxford University Press.

4) Artificial Intelligence and Intelligent Systems, 1st Edition, N. P. Padhy, Oxford

University Press.

14.74 Data Base Management System

14.74.1 Introduction of the Course

Course Code and Title: 0612-CSE-4263: Data Base Management System.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the principles and practices of database systems, which are foundational to managing data in modern engineering applications. This course equips students with the theoretical knowledge and practical skills needed to design, implement, and manage robust database solutions that support data-driven decision-making and efficient information management. By exploring the course, students will be prepared to tackle complex data management challenges in various engineering and industrial contexts, ensuring data integrity, security, and optimal performance.

Prerequisites (if any): 0612-CSE-4163: Data and Computer Network.

14.74.2 Course Objectives

The students are expected to

1) Understand the fundamental concepts of database management systems and the overall structure of a database.

2) Develop a strong foundation in data modeling techniques, and apply these techniques to design conceptual and logical database schemes.

3) Gain proficiency in SQL for database application development, and the use of advanced SQL features.

4) Comprehend the principles of relational database design, and apply these principles to create efficient, well-structured database designs.

5) Explore advanced topics in DBMS implementation and modern database systems, and emerging database technologies.

14.74.3 Course Content

Introduction: General Overview and Purpose of DBMS, Advantages, Applications, Common Features and Overall Structure of the Database.

Data Modelling: Relational Model: Structure of Relational Model, Key Constraints, Referential Integrity Constraints, General Constraints, Relational Algebra – Fundamental, Additional and Extended Operations, Aggregate Functions, Outer Joins and Database Modification using RA, ER Model: Entity and Relationship Sets, Constraints – Key, Mapping Cardinality and Participation Constraints, Strong and Weak Entity Sets, E-R Diagram, Class Hierarchies, Aggregation, Conceptual Database Design with the ER Model, Converting ER to Relational Model, Object-Relational Data Model: Complex Data Types, Structured Types and Inheritance, Implementing O-R Features.

Relational Database Design: Features of Good Relational Design, Functional Dependency Theory - Basic Concept, Uses, Closure of a Set of FDs, Closure of Attribute Sets, Canonical Cover, Algorithms for FDs, Decomposition using FDs and its Desirable Properties, Atomic

Domains and First Normal Form, BCNF and 3NF, Multivalued Dependencies and Fourth Normal Form, Decomposition Algorithms for Different Normal Forms, Database Design Process.

Database Application Development: Database Management Systems (DBMSs), SQL: Data Definition and Data Manipulation Languages, Integrity Constraints, Basic Queries, Nested and Complex Queries, Modification of the Database, Views: Definition, Update on Views, Cursors, Extending DBMS Functionality: Stored Procedures, Assertions and Triggers, Embedded and Dynamic SQL, DBMS Administration: DBA, Users, Privileges, Security, Performance, ODBC, JDBC, Web/Database Architectures.

DBMS Implementation Technology: Storage and File Structure: Different Storage Types, File and Record Organization, Data Dictionary Storage, Indexing and Hashing: Basic Concepts, Ordered Indices, B+-Tree Index Files, B-Tree Index Files, Static and Dynamic Hashing, Comparison of Ordered Indexing and Hashing.

Query Processing: Overview, Measures of Query Costs, Selection Operation, Sorting, Join Operation, Other Operations, Evaluation of Expressions, Query Optimization: Introduction, Transformation of Relational Expressions, Evaluation Plan.

Transaction Processing: Transactions: Concepts, ACID Properties, Transaction States, Concurrent Schedules, Serializability - Conflict and View Serializability, Recoverability, Concurrency Control: Lock-Based Concurrency Control, Two- Phase Locking, Problems with Locking, Locking and Starvation, Deadlock– Prevention, Detection and Recovery.

Introduction to Modern Database Systems: Object-Relational Databases, Deductive Databases, Spatial Databases, Temporal Databases, Multimedia Databases, Mobile Databases and Advanced Relational Databases.

14.74.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the fundamental concepts of database management systems, and the overall structure of databases	PO1, PO2	C1, C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Design and implement conceptual and logical database schemes using data modeling techniques	PO1, PO2, PO3	C3, C4	Lectures Discussions Exercise	Assignment Final Exam
CO3	Develop and execute SQL	PO1, PO5	C3	Lectures Discussions	Assignment

	queries for database application development			Exercise	Final Exam
CO4	Apply principles of relational database design to create efficient database structures, and explore advanced topics	PO1, PO2, PO3	C4, C5	Lectures Discussions	Incourse Final Exam Presentation

14.74.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓		✓	✓	✓			✓		✓		✓					✓	✓	✓

14.74.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction: General Overview and Purpose of DBMS, Advantages, Applications, Common Features and Overall Structure of the Database Relational Model: Structure of Relational Model, Key Constraints, Referential Integrity Constraints, General Constraints	CO1
2	3-4	Relational Algebra: Fundamental, Additional and Extended Operations, Aggregate Functions, Outer Joins, Database Modification using RA ER Model: Entity and Relationship Sets, Constraints – Key, Mapping Cardinality and Participation Constraints, Strong and Weak Entity Sets	CO2
3	5-6	ER Model: E-R Diagram, Class Hierarchies, Aggregation, Conceptual Database Design with the ER Model Converting ER to Relational Model, Object-Relational Data Model: Complex Data Types, Structured Types and Inheritance, Implementing O-R Features	CO2
4	7-8	Relational Database Design: Features of Good Relational Design, Functional Dependency Theory - Basic Concept, Uses, Closure of a Set of FDs, Closure of Attribute Sets	CO4
5	9-10	Canonical Cover, Algorithms for FDs, Decomposition using FDs and its Desirable Properties, Atomic Domains and First Normal Form	CO4

		BCNF and 3NF, Multivalued Dependencies and Fourth Normal Form, Decomposition Algorithms for Different Normal Forms, Database Design Process	
6	11-12	Database Application Development: SQL: Data Definition and Data Manipulation Languages, Integrity Constraints, Basic Queries, Nested and Complex Queries Modification of the Database, Views: Definition, Update on Views, Cursors, Extending DBMS Functionality: Stored Procedures, Assertions and Triggers	CO3
7	13-14	Embedded and Dynamic SQL, DBMS Administration: DBA, Users, Privileges, Security, Performance, ODBC, JDBC, Web/Database Architectures	CO3, CO4
8	15-16	Storage and File Structure: Different Storage Types, File and Record Organization, Data Dictionary Storage, Indexing and Hashing: Basic Concepts	CO4
9	17-18	Ordered Indices, B+-Tree Index Files, B-Tree Index Files, Static and Dynamic Hashing, Comparison of Ordered Indexing and Hashing	CO4
10-11	19-22	Query Processing: Overview, Measures of Query Costs, Selection Operation, Sorting, Join Operation, Other Operations, Evaluation of Expressions Query Optimization: Introduction, Transformation of Relational Expressions, Evaluation Plan	CO4
12	23-24	Transaction Processing: Transactions: Concepts, ACID Properties, Transaction States, Concurrent Schedules, Serializability - Conflict and View Serializability, Recoverability	CO4
13	25-26	Concurrency Control: Lock-Based Concurrency Control, Two-Phase Locking, Problems with Locking, Locking and Starvation, Deadlock–Prevention, Detection and Recovery	CO4
14	27-28	Introduction to Modern Database Systems: Object-Relational Databases, Deductive Databases, Spatial Databases Introduction to Modern Database Systems: Temporal Databases, Multimedia Databases, Mobile Databases and Advanced Relational Databases	CO4

14.74.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.74.8 Text Books and Reference Books

1) Principles of Database Management, 1st Edition, Wilfried Lemahieu, Seppe vanden Broucke, and Bart Baesens, Cambridge University Press.

2) Introduction to Database Management, Mark L. Gillenson, Wiley.

3) Fundamentals of Database Systems, 7th Edition, Ramez Elmasri and Shamkant B. Navathe, Pearson.

4) Database System Concepts, 6th Edition, Abraham Silberschatz Professor, Henry F. Korth, and S. Sudarshan, McGraw-Hill Education.

5) Database Systems Design, Implementation, and Management, Carlos Coronel, Steven Morris, Peter Rob, Course Technology.

14.75 Renewable Energy Technology

14.75.1 Introduction of the Course

Course Code and Title: 0713-EEE-4271: Renewable Energy Technology

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week

Rationale of the Course: The growing global demand for sustainable and clean energy solutions necessitates a comprehensive understanding of renewable energy technologies. This course provides students with the theoretical foundations and practical insights into the principles, design, and applications of renewable energy systems, emphasizing solar energy. It equips students with the knowledge and skills required to address energy challenges and contributes to the development of environmentally friendly energy solutions, thereby supporting the transition to a low-carbon future

Prerequisites (if any): No prerequisite.

14.75.2 Course Objectives

The students are expected to

1) Understand the principles of energy conversion in renewable energy technologies.

2) Analyze the performance and optimization of renewable energy systems.

3) Gain proficiency in the design and sizing of solar photovoltaic (PV) systems for various applications.

4) Explore emerging renewable energy technologies and evaluate their environmental and economic impacts

14.75.3 Course Content

Radiations: Radiation Characteristics of Materials: Absorptance, Emittance, Reflectance and Selective Surfaces, Modes of Heat Transfer.

Solar Collectors: Flat Plate Collectors, Concentrating Collectors, Solar Distillation, Solar Energy Systems for Process Heating, Solar Thermal Power Generation, Solar Refrigeration, Solar Thermal System Optimization and Performance Study, Solar Thermal Modeling.

Solar Photovoltaic Energy Conversion: Solar Cell Fundamental, Basic Principle, Types of Solar Cells, P-N Junction as Photovoltaic Cell, Heterojunction, Schottky Barrier Junction, Fabrication of Solar Cell, Effect of Irradiance and Temperature on Solar Cells, Effect of Shading, hotspot formation, Thin-Film Solar Cell, Multi- Sun Solar Cells, Fabrication of Photovoltaic Modules, Dimension of Cells, Packing Efficiency of Cells in Modules, Characterization of Cells and Modules, Organic and Polymer Matrix for the Fabrication of Solar Cell, Nanostructure Solar Cell.

Storage and Power Conditioning System: Batteries- Construction, Operation, DoD, Efficiency etc. Battery Charge Controllers. Inverters, Maximum Power Point Trackers (MPPT).

Different Types of PV System: Stand-Alone PV System. Solar Home System, Grid-Tied PV System and Hybrid System, Design of PV System, Stand Alone PV System Sizing.

Other Non-Conventional Energy Options: Wind, Geothermal, OTEC, Wave Energy, Biomass, MHD, Chemical Energy, Fuel Cell, Hydro Energy, Nuclear Fission and Fusion.

14.75.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate an understanding of the principles and components of renewable energy technologies.	PO1, PO7	C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Analyze the performance and efficiency of solar thermal and photovoltaic systems under varying conditions.	PO2, PO4	C4	Lectures Discussions Handouts	Incourse Final Exam
CO3	Design solar PV systems,	PO3, PO5, PO7	C5	Lectures Discussions	Assignment Final Exam

	considering technical, environmental, and economic aspects.			Exercise	
CO4	Evaluate the feasibility of emerging renewable energy options for specific applications.	PO7, PO12	C6	Lectures Discussions	Incourse Final Exam

14.75.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓				✓	✓	✓						✓	✓	✓	✓				

14.75.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Introduction to renewable energy, global energy scenario, and the need for renewable energy. Overview of renewable energy technologies: Solar, wind, geothermal, and more.	CO1
2	3-4	Radiation characteristics of materials: Absorptance, emittance, reflectance, and selective surfaces. Modes of heat transfer and their relevance in solar energy systems.	CO1
3	5-6	Solar collectors: Flat plate collectors, concentrating collectors, and their applications. Solar thermal systems: Process heating, power generation, refrigeration, and optimization.	CO1, CO2
4	7	Solar thermal modeling and performance study of solar thermal systems.	CO2
4-5	8-10	Fundamentals of solar photovoltaic energy conversion and types of solar cells. P-N junction as photovoltaic cell: Principles, heterojunction, and Schottky barrier junction.	CO1
6	11-12	Fabrication of solar cells and modules: Dimensions, efficiency, and characterization.	CO1, CO2
7	13	Performance characteristics of solar cells: Effects of irradiance, temperature, and shading.	CO2

7	14	Advanced solar cells: Thin-film, multijunction, organic, polymer matrix, and nanostructure solar cells.	CO1, CO2
8	15-16	Batteries in renewable energy systems: Construction, operation, depth of discharge (DoD), and efficiency.	CO1
9	17	Battery charge controllers and inverters: Principles and performance analysis.	CO2
9	18	Maximum Power Point Trackers (MPPT): Design and operation.	CO2, CO3
10-11	19-22	Different types of PV systems: Stand-alone, grid-tied, and hybrid systems. Sizing and designing stand-alone PV systems. Solar home systems: Components, design considerations, and applications.	CO3
12	23-24	Feasibility analysis of PV systems: Technical, environmental, and economic aspects. RETScreen software: Basics and applications in renewable energy feasibility studies.	CO4
13-14	25-28	Emerging renewable energy technologies: Wind, geothermal, and wave energy systems. Overview of OTEC, MHD, biomass, and chemical energy systems. Fuel cells: Principles, types, and applications in renewable energy systems. Hydro energy and nuclear energy: Fundamentals, advantages, and challenges. Carbon Footprint.	CO4

14.75.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%

Total	100%

14.75.8 Text Books and Reference Books

1) Applied Photovoltaics, 3rd Edition, Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish and Alistair Sproul, Routledge.

2) Handbook of Photovoltaic Science and Engineering, 2nd Edition, Antonio Luque, Steven Hegedus, Wiley.

3) Physics of Solar Cells, 1st Edition, Jenny Nelson, Imperial College Press.

4) Fundamentals of Solar Cells: Photovoltaic Solar Energy Conversion, Paperback, Richard H. Bube, Academic Press.

5) Photovoltaic Systems Engineering, 3rd Edition, Roger A. Messenger and Amir Abtahi, CRC Press.

6) Solar Engineering of Thermal Processes, 4th Edition, John A. Duffie (Author), William A. Beckman, Wiley.

7) Solar Cells: Operating Principles, Technology and System Applications, Martin A. Green, University of New South Wales Press.

8) Renewable Energy: Power for a Sustainable Future, 3rd Edition, Godfrey Boyle, Oxford University Press.

9) Renewable Energy: A Primer for the Twenty-First Century, Bruce Usher, Columbia University Press.

10) Introduction to Renewable Energy for Engineers, 1st Edition, Kirk D. Hagen, Pearson.

14.76 Renewable Energy Technology Laboratory

14.76.1 Introduction of the Course

Course Code and Title: 0713-EEE-4272: Renewable Energy Technology Laboratory

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week

Rationale of the Course: This course is designed to provide students with hands-on experience in renewable energy systems and their applications. With the increasing global emphasis on sustainable energy solutions, this course aims to equip students with practical skills in designing, testing, and analyzing renewable energy technologies such as solar, wind, and bioenergy systems.

Prerequisites (if any): No prerequisites is required.

14.76.2 Course Objectives

The students are expected to

1) Gain practical skills in the setup and operation of renewable energy systems.

2) Develop a practical understanding of renewable energy technologies and their applications through laboratory experiments.

3) Design and evaluate renewable energy solutions, emphasizing efficiency, feasibility, and sustainability.

4) Foster teamwork, problem-solving, and communication skills through collaborative projects and presentations.

14.76.3 Course Content

Experiments in relevance with the EEE 4271 Renewable Energy Technology course.

Projects related to EEE 4271 Renewable Energy Technology course contents to achieve specific program outcomes.

14.76.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate proficiency in setting up and operating renewable energy laboratory equipment and systems.	PO1, PO5	C3, A4, P5	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva
CO2	Analyze and interpret experimental data to evaluate the performance of renewable energy technologies.	PO2, PO4	C4	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva
CO3	Apply problem-solving skills to design and troubleshoot renewable energy experiments and projects.	PO3, PO5	C5, A4, P5	Simulation, Experiment, Group discussion, Project	Lab reports, Project report, Presentation, Viva, Quiz
CO4	Assess the technical, environmental, and economic feasibility of renewable energy systems through experimental	PO4, PO7, PO12	C6, A5	Lectures, Simulation, Experiment	Assignment, Reports, Lab test, Viva

	data and tools like RETscreen.				

14.76.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓			✓	✓	✓	✓				✓	✓		✓				✓	✓	

14.76.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs
1	Introduction	Introduction and overview of experiments and projects; Formation of groups/teams for design projects and laboratory works	---
2	Experiment 01	Prediction of total solar radiation on a tilted surface from measured total and diffuse solar radiation on a horizontal surface.	CO2
3	Experiment 02	Prediction of direct normal irradiance (DNI) from measured total and diffuse radiation on a horizontal surface.	CO2
4	Experiment 03	Study the I-V characteristics of a solar module.	CO1
5	Experiment 04	Design and construct a charge controller circuit.	CO3
6	Experiment 05	Performance analysis of a charge controller circuit.	CO2, CO3
7	Experiment 06	Study the performance of an inverter.	CO1
8	Experiment 07	Design and study a solar home system.	CO3
9	Experiment 08	Feasibility study of an off-grid PV system using "RETscreen".	CO4
10	Experiment	Review of Experiment 01 to 08	---
11	Project Proposal Presentation	Distribution of projects among different teams; Describe specific technical requirements to be attained during the project	---
12-13	Final Exam	Experiment 01 to 08	CO1, CO2, CO3, CO4
14	Project Demonstration and Final presentation	Use multimedia and necessary documentation to clearly communicate the project; Show evidence that specific technical requirements have been attained by the project	CO3, CO4

14.76.7 Assessment Pattern/ Strategy

Assessment will be based on lab participation and performance, quality lab reports, completion of projects involving renewable energy technologies and systems, and depth of understanding and ability to explain results of the experiments.

Distribution of marks:

Class Attendance	10%
Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.76.8 Text Books and Reference Books

1) Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems – Arno Smets et al., UIT Cambridge Ltd.

2) Handbook of Renewable Energy Technology – Edited by Zobaa & Bansal, World Scientific.

3) Photovoltaic Systems" – James P. Dunlop, 3rd Edition, American Technical Publishers.

14.77 Project Work

14.77.1 Introduction of the Course

Course Code and Title: 0714-EEE-4200: Project Work.

Credits and Contact Hours: 4.0 Credits, 8 Contact Hours per Week.

Rationale of the Course: This course offers students a comprehensive exploration of experimental and theoretical investigations within electrical and electronic engineering. Building upon their foundational project work from the previous semester, students apply first principles in mathematical, natural, and engineering sciences, designing experiments, analyzing data, and synthesizing information. This dynamic course cultivates critical thinking, research acumen, and ethical responsibility, guiding students to become adept researchers who navigate complex challenges with technical expertise and ethical integrity.

Prerequisites (if any): 0714-EEE-4100: Project Work.

14.77.2 Course Objectives

The students are expected to

1) Equip students with advanced research skills within the field of electrical and electronic engineering.

2) Enable students to translate theoretical knowledge into practical applications through hands-on experiences, including simulations and experiments.

3) Develop students' proficiency in conducting comprehensive data analysis on simulation and experimental results.

4) Comprehend and adhere to professional ethics and ethical principles of research.

5) Enhance written and oral communication skills for effectively conveying research findings.

6) Acquire project management skills to plan and execute research activities efficiently.

7) Cultivate a mindset of continuous learning and adaptation in the dynamic field of electrical and electronic engineering.

14.77.3 Course Content

Students will engage in both experimental and theoretical investigations focusing on a research topic within the field of electrical and electronic engineering. Building upon the project work undertaken in the previous semester, they will interpret data, analyze problems using the first principles of mathematical, natural, or engineering sciences, and conduct investigations utilizing research-based knowledge and methodologies, including the design of experiments, analysis and interpretation of data, and synthesis of information to draw valid conclusions.

Additionally, students will be expected to comprehend and adhere to professional ethics and ethical principles of research.

14.77.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate the ability to deliver concise and effective technical presentations	PO10	A2	Discussion Experiment Simulation	Report Presentation
CO2	Exhibit the ability to translate theoretical knowledge into practical applications	PO1	C3		
CO3	Develop proficiency in conducting comprehensive data analysis on simulation and experimental results	PO1, PO4	C4		

CO4	Comprehend and apply professional ethics and ethical principles of research	PO6, PO8	A3, A5		
CO5	Acquire project management skills to efficiently plan and execute research activities	PO9, PO11	C3, P7		

14.77.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
	✓				✓	✓		✓	✓	✓				✓	✓	✓	✓		✓

14.77.6 Course Structure/ Lecture Plan

Weekly meeting and discussion with supervisor regarding project work.

Final Week of the Semester: 1) Project report submission
2) Oral presentation of the project work

14.77.7 Assessment Pattern/ Strategy

At the end of the semester, each student is required to submit a comprehensive project report for evaluation. Additionally, each student must orally present their project work, and respond to questions from both examiners and the audience.

Distribution of marks:

Project Report	50%
Project Presentation	50%
Total	100%

14.77.8 Text Books and Reference Books

N/A

14.78 Big Data Analysis

14.78.1 Introduction of the Course

Course Code and Title: 0613-CSE-4165: Big Data Analysis.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The ability to handle, process, and analyze vast amounts of data is essential for making informed decisions, optimizing processes, and driving innovation. This course provides students with a comprehensive understanding of big data concepts, technologies, and techniques, equipping them with the skills necessary to tackle real-world data challenges. By exploring various big data applications, machine learning algorithms, and data processing frameworks, students will be prepared to leverage big data analytics to improve system efficiencies and develop advanced technological solutions.

Prerequisites (if any): 0542-STA-2207: Probability and Statistics, 0612-CSE-4163: Data and Computer Network.

14.78.2 Course Objectives

The students are expected to

1) Understand the fundamental concepts and importance of big data, and the infrastructure required for big data analytics.

2) Gain proficiency in mining and analyzing data streams, utilizing real-time analytics platforms and various techniques for sampling, filtering, and counting distinct elements in data streams.

3) Explore and apply various big data technologies to address complex data challenges.

4) Develop skills in big data processing and machine learning, and deep learning algorithms to analyze and interpret large datasets.

14.78.3 Course Content

Introduction: Big Data and its Importance, Big Data Characteristics, Types of Big Data, Infrastructure for Big Data, Big Data Analytics Applications.

Mining Data Streams: Introduction to Stream Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Real-Time Analytics Platform (RTAP) Applications.

Big Data Technologies: Open Source Technology for Big Data Analytics, Cloud and Big Data, Predictive Analytics, Crowd- sourcing Analytics, Inter-Firewall and Trans-Firewall Analytics, Information Management.

Big Data Processing: Integrating Disparate Data Stores, Mapping Data to Programming Framework, Connecting and Extracting Data from Storage, Transforming Data for Processing, Map Reduce Types, Formats and Features, Hadoop Environment, Sub-dividing Data for Hadoop Map Reduce.

Machine Learning: Distributed Computing for Big Data, Machine Learning Regression and Classification Models, Deep Learning Algorithm, Training Deep Neural Network (DNN), Use of Auto-Encoders, Dropout Regularization and Early Termination of DNN, Text Analytics, Natural Language Processing.

14.78.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the fundamental concepts,	PO1, PO2	C2	Lectures Discussions Handouts	Incourse Final Exam

	importance, and characteristics of big data, as well as the infrastructure required for big data analytics				
CO2	Analyze and process data streams using different techniques, and utilize real-time analytics platforms for stream computing	PO1, PO2, PO4	C4	Lectures Discussions Exercise	Assignment Final Exam
CO3	Apply various big data technologies to solve complex data challenges	PO1, PO2, PO3, PO5	C3, P4	Lectures Discussions Exercise	Assignment Final Exam
CO4	Implement big data processing techniques and machine learning algorithms to extract insights and value from large datasets	PO1, PO2, PO3, PO4, PO5	C5, P5	Lectures Discussions	Incourse Final Exam Presentation

14.78.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓			✓	✓			✓				✓	✓		✓				✓

14.78.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Introduction: Big Data and its Importance, Big Data Characteristics, Types of Big Data Infrastructure for Big Data, Big Data Analytics Applications	CO1
3-4	5-8	Introduction to Stream Concepts, Stream Data Model and Architecture	CO2

		Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream	
5	9-10	Real-Time Analytics Platform (RTAP) Applications	CO2
6-7	11-14	Open Source Technology for Big Data Analytics, Cloud and Big Data Predictive Analytics, Crowd-sourcing Analytics, Inter-Firewall and Trans-Firewall Analytics	CO3
8	15-16	Information Management, Integrating Disparate Data Stores, Mapping Data to Programming Framework	CO3, CO4
9	17-18	Connecting and Extracting Data from Storage, Transforming Data for Processing	CO4
10-11	19-22	Map Reduce Types, Formats and Features, Hadoop Environment Sub-dividing Data for Hadoop Map Reduce, Distributed Computing for Big Data	CO4
12	23-24	Machine Learning Regression and Classification Models, Deep Learning Algorithm	CO4
13	25-26	Training Deep Neural Network (DNN), Use of Auto-Encoders, Dropout Regularization and Early Termination of DNN	CO4
14	27-28	Text Analytics, Natural Language Processing	CO4

14.78.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.78.8 Text Books and Reference Books

1) Big Data Analytics, 1st Edition, S. Acharys and S. Chellappan, Wiley.

2) Intelligent data Analysis-An Introduction, 2nd Edition, M. Berthold and D. J. Hand, Springer.

3) Understanding Big Data Analytics for Enterprise Class, Hadoop and Streaming Data, P. C. Zikopoulos, C. Eaton, D. deRoos, T. Deutsch and G. Lapis, McGraw-Hill.

4) Data Mining Concepts and Techniques, 2nd Edition, J. Han and M. Kamber, Elsevier.

14.79 Object Oriented Programming

14.79.1 Introduction of the Course

Course Code and Title: 0613-CSE-4167: Object Oriented Programming.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students with a profound understanding of Object Oriented Programming principles and their applications. This course aims to impart the advantages of OOP over structured programming, guiding students through essential concepts such as encapsulation, inheritance, and polymorphism. By exploring languages like C++ and Java, students will gain crucial skills to model problems systematically, design efficient solutions, and implement robust, maintainable software systems. By the end, students will be ready to solve real-world problems using smart and organized coding techniques, making them skilled and creative programmers.

Prerequisites (if any): 0613-CSE-1205: Computer Programming.

14.79.2 Course Objectives

The students are expected to

1) Develop a strong comprehension of Object-Oriented Programming (OOP) principles and their significance in software development.

2) Acquire proficiency in key OOP concepts such as encapsulation, inheritance, polymorphism, and modularity.

3) Explore and apply OOP concepts in practical programming languages like C++ and Java.

4) Learn and apply organized coding techniques to effectively solve complex programming challenges using OOP principles.

14.79.3 Course Content

Overview: Philosophy of Object Oriented Programming (OOP), Advantages of OOP over Structured Programming.

Object Oriented Concepts: Modeling Problems using Object Oriented Concepts: Modularity, Encapsulation/Data Hiding, Immutability, Inheritance and Polymorphism, Object Oriented vs. Procedural Programming, Basics of Object Oriented Programming Language, Introduction to UML.

Objects and Classes: Attributes and Functions, Identifying Classes, UML Class Diagrams, Access Modifiers, Parameterised Types (Generics).

Pointers, References and Memory: Pointers and References, Reference Types, The Call Stack, The Heap, Iteration and Recursion, Pass-By-Value and Pass-By- Reference.

Lifecycle of an Object: Constructors and Chaining, Destructors, Finalizers, Garbage Collection: Reference Counting, Tracing, Functions or Methods, Overloading Methods, Access Control, Special Considerations in Different Languages.

I/O: Stream and Files: Output Streams, Input Streams, File Streams, String Streams.

Inheritance: Inheriting Classes, Subclass, Super Class, Access Control, Inheritance Hierarchy, Casting, Shadowing, Overloading, Overriding, Dynamic Binding, Abstract Class, Inner Classes, Special Considerations in Different Languages, Multiple Inheritance, Interfaces.

Exception and Exception Handling: Exception Handling Fundamentals, Exception Types, Chained Exception, Creating Own Exception Subclasses or Custom Exceptions, Checked vs Unchecked, Inappropriate use of Exceptions, Assertions.

Copying Objects: Shallow and Deep Copies, Copy Constructors, Cloning, Cloneable as a Marker Interface.

Generics or Templates: Template Functions and Classes, Multi-Threaded Programming, Special Considerations in Different Languages.

Package/Namespace: Understanding and Implementing Package/Namespace.

Object-Oriented Design Principles and Examples: Introduction to Object- Oriented Design Principles and Examples, Introduction to Design Patterns, Open- Closed Principle, Examples of Singleton, Decorator, State, Composite, Strategy, Observer.

Case Study Using Object Oriented Programming [Reference Languages: C++ and Java].

14.79.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Develop a solid understanding of Object-Oriented Programming (OOP) principles	PO1	C1, A1	Lectures Handouts Discussions	Incourse Presentation Final Exam
CO2	Exhibit proficiency in applying key OOP concepts in practical programming languages to solve real-world problems	PO3, PO5	C3, C5, A4	Lectures Handouts Discussions	Incourse Presentation Final Exam
CO3	Employ organized coding techniques to address complex	PO2	C3, A4	Lectures Exercise	Assignment Final Exam

	programming challenges				

14.79.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓		✓	✓			✓	✓	✓	✓				✓		✓		✓

14.79.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Structured Programming, Object-Oriented Programming, Event-Driven Programming, Visual Programming, Early Procedural Programs, Modularity and Abstraction, Encapsulation, Evolution of Object Model, Foundations of Object Model, Elements of Object Model, Applying Object Model	CO1
2-3	3-6	Nature of Object, Relationships among Objects, Nature of Class, Relationships among Classes, Identifying Classes and Objects, Interplay of Classes and Objects, Building Quality Classes and Objects, Inheritance, Polymorphism	CO1
4	7-8	Introduction to UML, UML Class diagrams, UML Syntax, UML Package Diagrams, UML Object Diagrams UML, Sequence Diagrams	CO1
5-6	9-12	Understanding Memory Addresses, Arrays and Pointers, Storing, Accessing and Using Array Values, Creating Arrays of Structure Objects, 2-D Arrays, String Arrays, Procedural Abstraction, Scope, Returning Values from Function, Passing Values to Function, Using Objects as Parameters and Return Types, Reference Variables, Passing Addresses and Arrays	CO2 CO3
7	13-14	Creating Classes, Encapsulating Class Components, Implementing Functions in a Class, Static Class Members, Polymorphism, Constructors With and Without Parameters, Overloading Constructors, Destructors, Composition	CO2 CO3
8-9	15-18	Friends, Function as a Friend, Benefits of Overloading and Polymorphism, Overloading Operators, Overloading Input, Overloading Output, Inheritance, Derived Class, Inheritance Restriction, Class Access Specifier, Overriding Inherited Access, Base Class Construction, Multiple Inheritance	CO2 CO3
10	19-20	Creating Function Templates, Using Multiple Parameters in Function Templates, Overloading Function Templates, Using Multiple Type in Function Templates, Class	CO2 CO3

		Templates, Container Classes, Array Template Class, Standard Template Library	
11	21-22	Throwing, Catching and Rethrowing Exceptions, Exception Handler, Exception Classes, Exception Specifications, Handling Memory Allocation Exception, CIN and COUT as Objects, ISTREAM and OSTREAM Member Functions, Manipulators, File Output and Input, Writing and Reading Objects	CO2 CO3
12-13	23-26	Case Projects 1-4	CO2 CO3
14	27-28	Final Presentation on Case Projects	---

14.79.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.79.8 Text Books and Reference Books

1) Java: How to Program, Paul Deital and Harvey Deital, Prentice Hall.

2) C++ How to Program, Paul Deital and Harvey Deital, Pearson Education.

3) Java in a Nutshell: a Desktop Quick Reference, D. Flanagan, O'Reilly.

4) The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley.

5) C++ Primer, Stanley Lippman, Pearson Education.

6) Object Oriented Programming using C++, Robert Laffore, Sams Publishing.

7) Java the Complete Reference, Herbert Schildt, McGraw Hill.

8) Object-Oriented Analysis and Design with Applications, Grady Booch, Robert A. Maksmichuk, Michael W. Engle, Bobbi J. Young, Jim Conallen, Kelli A. Houston, Pearson Education.

9) UML Distilled, Martin Fowler, Pearson Education.

10) Design Patterns: Elements of Reusable Object-Oriented Software, Erich Gamma, Richard Helm, Ralph Johnson & John Vlissides, Addison-Wesley Professional.

11) Object-Oriented System Development, Ali Bahrami, Tata McGraw Hill.

12) Teach Yourself C++, Herbert Schildt, Osborne McGraw-Hill.

14.80 Advanced Semiconductor Devices

14.80.1 Introduction of the Course

Course Code and Title: 0714-EEE-4235: Advanced Semiconductor Devices.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is an advanced level course designed to develop students' knowledge on semiconductor devices that are now crucial for scheming modern electronic devices leading to develop an electronic chip. Thus, students will know the today's major concern of the semiconductor industry for making devices, such as, high-performance, small size, less power, high operating temperature, quantum devices, limitations of existing semiconductor technology, etc. Also, students will get to know the physics of the novel devices and upcoming semiconductor technology.

Prerequisites (if any): 0714-EEE-3109: Electronic Devices, 0714-EEE-3205: Materials Science, 0714-EEE-3207: Optoelectronics and Photonics.

14.80.2 Course Objectives

The students are expected to

1) Develop understanding on advanced semiconductor devices including their basic structure, operating principle, fabrication technology and applications.

2) Learn the details of the multigate devices, as well the challenges of the FinFET architecture and how to overcome through gate-all-around technology. Analyze the performance parameters of FinFET, Gate-All-Around MOSFET and other devices

3) Study tunneling devices, single electron transistor, CNT, and graphene-based devices. Also know their construction, operating principles, I-V characteristics, and other performance parameters.

4) Learn the basics of advanced FET devices, including their structure, operation, fabrication, and applications.

14.80.3 Course Content

Heterojunction Devices: Physics Background on Heterostructure, Quantum Well, Superlattice, Modulation Doping, Band Alignment, Band Offset, Anderson's Rule, Single and Double Sided Hetero-Junctions, Quantum Wells and Quantization Effects, Two-Dimensional Electron Gas (2DEG), Lattice Mismatch and Strain and Common Hetero-Structure Material Systems, High Electron Mobility Transistors (HEMTs) Devices: Operation Principle and I-V Characteristics.

Multigate Devices: Transistor and Multiple-Gate MOSFET's Development History, Issues in Short-Channel MOSFET Electrostatics, Scale Length Fundamentals for Thin-Body MOSFETs (FinFET, Planar Fully-Depleted SOI MOSFET and Gate-All-Around MOSFET), Advantages of Thin-Body MOSFET's Electrostatics Quantum Mechanical Effects, Effective Carrier Mobility, High-Field Velocities, Parasite Resistance, Thin-Body MOSFET's Carrier

Transport, Impacts of Substrate, Fin Shape Tuning, Gate Stack Process FinFET's Source/Drain Process, Multiple-Gate MOSFET's Threshold Voltage Engineering Multiple-Gate MOSFET Performance Dependence on Channel Orientation and Strain, Strained- Si Technology and its Effectiveness on Multiple-Gate MOSFETs, SoC Potentials For Multiple-Gate MOSFETs, 3-Dimensional Integrations, Reliability Issues.

Tunneling Devices: Resonant Tunneling Diodes: Physics and Operation, Resonant Tunneling Transistors, Device Physics, Operation and Characteristics.

Single Electron Transistor: Basic Device Physics, Operating Principle and I-V Characteristics, Coulomb Blockade and Coulomb Diamonds.

CNT, Graphene and 2D Semiconductor Devices: Basic Device Physics, Operating Principle and I-V Characteristics of CNT-FET, Graphene Devices, MOS2 and Transition Metal Dichalcogenide (TMD) Devices, 2D Memristors.

Spintronic Devices: Introduction to Spintronics, Quantum Mechanics of Spin, Spin-Orbit Interaction, Spin Relaxation, Spin Dependent Scattering, Tunneling and Transport, Spin Injection, Spin Transistor: Basic Operation and I-V Characteristics, Spin-Valve, Spin-Tunneling and Sensor Devices, Quantum Computing Devices.

Advanced FET Devices: Basic Device Physics, Operation Principle, I-V Characteristics and Fabrication of DNA-FETs, Detection Principle of Biological and Chemical FET Sensors, Negative Capacitance FETs, Transistors, Nanowire FETs, Organic FETs.

14.80.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand the basic structure and operations of different types of advanced semiconductor devices	PO1	C2	Lectures Discussions	Assignment Incourse Final Exam
CO2	Determine the device/material parameters from an experimental device characteristic	PO2	C3	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO3	Examine the performance parameters of different devices and identify the issues	PO4	C4	Lectures Discussions Exercise	Assignment Incourse Final Exam
CO4	Identify and compare the	PO2	C4	Lectures	Assignment Incourse

	technology and its limitations for fabricating the devices			Discussions Exercise	Final Exam

14.80.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓		✓	✓	✓	✓		✓	✓	✓						✓	✓		✓	

14.80.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Physics Background on Heterostructure, Quantum Well, Superlattice, Modulation Doping, Band Alignment, Band Offset, Anderson's Rule, Single and Double Sided Hetero-Junctions, Quantum Wells and Quantization Effects,	CO1
3	5-6	Two-Dimensional Electron Gas (2DEG), Lattice Mismatch and Strain and Common Hetero-Structure Material Systems, High Electron Mobility Transistors (HEMTs) Devices: Operation Principle and I-V Characteristics.	CO1
4-5	8-10	Multigate Devices: Transistor and Multiple-Gate MOSFET's Development History, Issues in Short-Channel MOSFET Electrostatics, Scale Length Fundamentals for Thin-Body MOSFETs (FinFET, Planar Fully-Depleted SOI MOSFET and Gate-All-Around MOSFET), Advantages of Thin-Body MOSFET's Electrostatics Quantum Mechanical Effects, Effective Carrier Mobility, High-Field Velocities, Parasite Resistance, Thin-Body MOSFET's Carrier Transport	CO2 CO3
6-7	11-14	Impacts of Substrate, Fin Shape Tuning, Gate Stack Process FinFET's Source/Drain Process, Multiple-Gate MOSFET's Threshold Voltage Engineering Multiple-Gate MOSFET Performance Dependence on Channel Orientation and Strain, Strained- Si Technology and its Effectiveness on Multiple-Gate MOSFETs, SoC Potentials For Multiple-Gate MOSFETs, 3-Dimensional Integrations, Reliability Issues.	CO3 CO4
8	15-16	Tunneling Devices: Resonant Tunneling Diodes: Physics and Operation, Resonant Tunneling Transistors, Device Physics, Operation and Characteristics.	CO1
9	17-18	Single Electron Transistor: Basic Device Physics, Operating Principle and I-V Characteristics, Coulomb Blockade and Coulomb Diamonds.	CO1
10	19-20	CNT, Graphene and 2D Semiconductor Devices: Basic Device Physics, Operating Principle and I-V Characteristics	CO1

		of CNT-FET, Graphene Devices, MOS2 and Transition Metal Dichalcogenide (TMD) Devices, 2D Memristors.	
11	21-22	Introduction to Spintronics, Quantum Mechanics of Spin, Spin-Orbit Interaction, Spin Relaxation, Spin Dependent Scattering, Tunneling and Transport, Spin Injection,	CO1 CO4
12	23-24	Spin Transistor: Basic Operation and I-V Characteristics, Spin-Valve, Spin-Tunneling and Sensor Devices, Quantum Computing Devices.	CO1 CO4
13-14	25-28	Advanced FET Device Physics, Operation Principle, I-V Characteristics and Fabrication of DNA-FETs, Detection Principle of Biological and Chemical FET Sensors, Negative Capacitance FETs, Transistors, Nanowire FETs, Organic FETs.	CO1

14.80.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment: 1 or 2 assignments will be given based on characteristics of different devices. In case of 2 assignments, their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.80.8 Text Books and Reference Books

1) Physics of Semiconductor Devices, 3rd Edition, S. M. Sze and Kwok K. Ng, Wiley.

2) Quantum Transport Atom to Transistor, S. Datta, Cambridge University Press.

3) Electronic Transport in Mesoscopic Systems, S. Datta, Cambridge University Press.

4) Semiconductor Spintronics and Quantum Computation, D.D. Awschalom, N. Samarath, and D. Loss, Springer.

5) Carbon Nanotubes: Properties and Applications, Michael J. O'Connell, CRC Press.

6) Fundamentals of Modern VLSI Devices, Y. Taur and T.H. Ning, Cambridge University Press.

7) FinFET and Other Multi-Gate Transistors, J.-P. Colinge, Springer.

8) Silicon-On-Insulator Technology, 3rd Edition, J.-P. Colinge, Springer.

14.81 Digital Image Processing

14.81.1 Introduction of the Course

Course Code and Title: 0714-EEE-4245: Digital Image Processing.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course provides students with essential knowledge and practical skills in image processing, reflecting its widespread applications in fields such as computer vision, medical imaging, remote sensing, and digital photography. Students can effectively interpret and manipulate digital images by understanding image fundamentals and gaining expertise in processing techniques, contributing to advancements in technology and innovation across various industries.

Prerequisites (if any): 0714-EEE-3105: Communication Systems, 0714-EEE-3203: Digital Signal Processing, 0714-EEE-3209: Communication Theory.

14.81.2 Course Objectives

The students are expected to

1) Understand image processing fundamentals.

2) Apply and analyze various image processing techniques for tasks such as enhancement, restoration, and compression.

14.81.3 Course Content

Introduction: Image Formation and Representation, Brightness Adaption and Discrimination, Pixels, Coordinate Conventions, Imaging Geometry, Perspective Projection and Transform, Image Acquisition and Digitization, Human Eyes and Visual Perception, Intensity Transformations and Spatial Filtering, Filtering in Frequency Domain.

Image Transformations: DFT, DCT Hadamar, and Haar, Image Restoration and Reconstruction, Introduction to Image Compression.

14.81.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand image formation, brightness adaptation, pixel properties, imaging geometry, and human visual perception.	PO1	C1, A1, A2	Lectures Discussions Exercise	Assignment Presentation Incourse Final Exam
CO2	Apply intensity transformations, spatial filtering,	PO2, PO3	C3, C5, A1	Lectures Discussions Exercise	Assignment Presentation Incourse

	and frequency domain filtering for image enhancement.			Handouts	Final Exam
CO3	Evaluate and implement image transformations (DFT, DCT, Hadamard, Haar) and gain introductory knowledge in image restoration, reconstruction, and compression techniques.	PO1, PO3	C2, C4, C5, A1, A4	Lectures Discussions Exercise	Assignment Presentation Incourse Final Exam

14.81.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓				✓	✓						✓	✓	✓		

14.81.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Image Formation and Representation	CO1
2	3	Brightness Adaption and Discrimination	CO1
2-3	4-5	Pixels, Coordinate Conventions	CO1
3-4	6-8	Imaging Geometry, Perspective Projection and Transform	CO1
5	9-10	Image Acquisition and Digitization Human Eyes and Visual Perception	CO1
6-7	11-13	Intensity Transformations and Spatial Filtering	CO2
7-8	14-16	Filtering in Frequency Domain	CO2
9-12	17-24	Image Transformations: DFT, DCT, Hadamar, and Haar	CO3
13	25-26	Image Restoration and Reconstruction	CO3
14	27-28	Introduction to Image Compression	CO3

14.81.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum of 1 Assignment and/or presentation; if 2 or more assignments or presentations are taken then their average will be considered in the final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.81.8 Text Books and Reference Books

1) Digital Image Processing, R. C. Gonzalez, R. E. Woods.

2) Fundamentals of Digital Image Processing, A. K. Jain, Prentice Hall of India, 1989.

14.82 Network and Information Security

14.82.1 Introduction of the Course

Course Code and Title: 0612-CSE-4247: Network and Information Security.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: In an increasingly interconnected digital world, Network and Information Security has become paramount to protecting sensitive data and maintaining trust in networked systems. This course provides a comprehensive understanding of security principles, cryptographic techniques, and defensive mechanisms essential for protecting data, networks, and systems. As cyber threats continue to grow in sophistication, organizations rely on skilled security professionals to design and implement robust security architectures that can withstand these attacks.

Prerequisites (if any): No prerequisite.

14.82.2 Course Objectives

In this age of universal electronic connectivity, of viruses and hackers, of electronic eavesdropping and electronic fraud, there is a dire need for individual and organization to respond to the global threat of cybercrime. The worldwide reliance on technology has created threats and vulnerabilities that require a security response. This course will introduce students to basic knowledge of the most current trends and issues related to computer, network, information and web security and the investigative and technical skills required to deal with these threats.

The students are expected to

1) Gain foundational knowledge of security goals, threats, and the OSI security architecture, enabling students to identify and mitigate potential attacks on networked systems.

2) Study and apply different cryptographic techniques to ensure data confidentiality, integrity and authenticity.

3) Understand and implement key management systems, including Public Key Infrastructure (PKI) and X.509 certificates, and user authentication protocols such as Kerberos.

4) Implement network layer security measures (e.g., IPsec), secure communication protocols (e.g., SSL, TLS), and wireless network security standards (e.g., IEEE 802.11i) to protect data in transit.

5) Study and implement intrusion detection systems (IDS), password management, antivirus strategies, and firewalls to protect against unauthorized access and malicious software.

6) Understand the legal frameworks and ethical responsibilities associated with cybersecurity, including compliance requirements and best practices for handling cybercrime.

14.82.3 Course Content

Overview: Security Goals, The OSI Security Architecture, Security Attacks, Services and Mechanism, A Model for Network Security.

Symmetric Ciphers: Classical Encryption Techniques, Block Ciphers and the Data Encryption Standard (DES), Basic Concepts in Number Theory and Finite Fields, Advanced Encryption Standard (AES), Block Cipher Operation, Pseudorandom Number Generation and Stream Ciphers.

Asymmetric Ciphers: Mathematics of Asymmetric-Key Cryptography, Public- Key Cryptography and RSA, Diffie-Hellman Key Exchange Algorithm, Man-in- the-Middle Attack, other Public-Key Cryptosystems.

Cryptographic Data Integrity Algorithms: Cryptographic Hash Functions: Secure Hash Algorithm (SHA), Message Authentication Codes: Security, Requirements, HMAC, Digital Signatures: Properties, Attacks and Forgeries, Digital Signature Standards.

Mutual Trust: Key Management and Distribution: Symmetric-Key Distribution, Public Key Distribution, Public Key Infrastructure, X.509 Certificates, User Authentication: Kerberos, Personal Identity Verification.

Network and Internet Security: Network Access Control and Cloud Security, Transport-Level Security: SSL, TLS, HTTPS and SSH, Wireless Network Security: IEEE 802.11i, Electronic Mail Security: PGP, S/MIME and DKIM, Network Layer Security: IPsec and Internet Key Exchange (IKE).

System Security: Intruders, Intrusion Detection System (IDS), Password Management, Malicious Software, Viruses, Worms, Antivirus Approaches, Distributed Denial of Service (DDoS) Attacks, Firewalls, Cybercrime: Legal and Ethical Aspects.

14.82.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand core security principles and threat model	PO1	C1, C2	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO2	Master different cryptographic techniques to ensure data confidentiality, integrity and authenticity	PO5	C1, P2	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO3	Design and deploy key management and user authentication mechanisms	PO3	C6, P4	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO4	Gain practical experience with security protocols and standards	PO12	C3, P4	Lectures, Discussion, Handout	Assignment In-course Final Exam
CO5	Develop skills in system security and intrusion detection	PO5, PO6	C6, P2	Lectures, Discussion, Handout	Assignment In-course Final Exam

14.82.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓			✓	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓		✓	✓

14.82.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Overview: Computer security concepts, security attacks, security services and security mechanisms	CO1
2-4	3-8	Symmetric Ciphers: Classical encryption techniques, block ciphers and DES, Basic concepts in number theory and finite fields, AES, Block cipher operation, Pseudorandom number generation and stream ciphers	CO2

5-6	9-12	Asymmetric Ciphers: Number theory related to Public key cryptography, RSA, Diffie-Hellman key exchange and other public key cryptosystems	CO2
7-8	13-16	Cryptographic Data integrity algorithms: Cryptographic hash functions, Message authentication codes, Digital signatures	CO2
9	17-18	Mutual Trust: Key management and distribution, User authentication protocols	CO3
10-11	19-22	Network and Internet Security: Transport level security, Wireless network security, Electronic mail security, IP security	CO4
12-14	23-28	System Security: Intruders, Malicious software, Firewalls Cybercrime: Legal and Ethical Aspects	CO5

14.82.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.82.8 Text Books and Reference Books

1) Network Security: Private Communication in a Public World, Kaufman, C, Perlman, R and Speciner, M., Prentice Hall.

2) Applied Cryptography, Schneier, B., John Wiley.

3) Cryptography and Network Security Principles and Practice, William Stallings, Pearson education.

4) Cryptography and Network Security, Behrouz A. Forouzan and Debdeep Mukhopadhyay, McGraw Hill education.

5) Security Engineering, Ross Anderson, Wiley.

6) Cryptography Engineering Design Principles and Practical Applications, Ferguson, Schneier, and Kohno, John Wiley & Sons.

7) Introduction to Computer Security, Matt Bishop, Addison Wesley Professional.

8) Computer Security: Principles and Practice, William Stallings, Pearson education.

9) Security in Computing, Charles Pfleeger, Prentice Hall.

10) Introduction to Computer Security, Michael Goodrich and Roberto Tamassia, Addison Wesley.

14.83 High Voltage Engineering

14.83.1 Introduction of the Course

Course Code and Title: 0713-EEE-4255: High Voltage Engineering.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This is a comprehensive course on electrical high voltage engineering focusing on high voltage DC and AC generation and transmission, high voltage accessories, protection, their measurement and testing. Knowledge obtained from this course will help students to work directly in any power system industry.

Prerequisites (if any): 0713-EEE-3201: Power System I, 0713-EEE-4151: Power System II, 0713 4101: Power Electronics, 0713-EEE-4153: Power System Protection.

14.83.2 Course Objectives

The students are expected to

1) Understand the fundamentals of high voltage engineering such as high voltage generation, measurements, voltage stress, materials strengths under high voltage, insulation coordination.

2) Understand high voltage testing facilities and the basics of high voltage laboratory.

3) Build the theoretical foundation for understanding and solving high voltage related problems in power systems.

4) Develop basis skills for high voltage insulation and protection design.

14.83.3 Course Content

High Voltage DC Generation: DC Generation, Rectifier Circuits, Voltage Multipliers, Van de Graaf and Electrostatic Generators, Applications.

High Voltage DC Transmission Grids: DC Grid Planning, Topology, Power- Transfer Security, DC Grids with Line-Commutated Converters, DC Grids with Voltage Source Converters, DC Grid Control, DC Grid Fault Management and DC Circuit Breakers.

High Voltage AC Generation: AC Generation, Cascaded Transformers and Tesla Coils, Impulse Voltage: Shapes, Mathematical Analysis, Codes and Standards, Single and Multi-Stage Impulse Generators, Tripping and Control of Impulse Generators.

High Voltage Protection: Breakdown in Gas, Liquid and Solid Dielectric Materials, Corona, High Voltage Measurements and Testing, Over-Voltage Phenomenon and Insulation Coordination, Lightning and Switching Surges, Basic Insulation Level, Surge Diverters and Arresters.

High Voltage Measurements and Testing: IEC and IEEE Standards, Sphere Gap, Electrostatic Voltmeter, Potential Divider, Schering Bridge, Megaohm Meter, HV Current and Voltage Transducers: Contact and Noncontact.

14.83.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Understand requirements and standards and employ electrical and electronic circuits for high voltage generation	PO1, PO2	C1, C2, C3	Lectures Discussions Homework	Assignment Incourse Final exam
CO2	Apply physical laws to explain high voltage breakdown of gas, liquid and solid dielectrics	PO1, PO2	C1, C2, C4	Lectures Discussions Homework	Assignment Incourse Final exam
CO3	Design high voltage measurement devices and analyze their characteristics for high voltage measurements	PO1, PO2, PO3	C1, C2, C3, C4	Lectures Discussions Homework	Assignment Incourse Final exam
CO4	Understand and employ statistical approach to insulation coordination correlating insulation and protection level	PO1, PO2	C1, C3, C4	Lectures Discussions Homework	Assignment Incourse Final exam
CO5	Identify and analyze high voltage phenomena relevant to engineering systems and specify the	PO1, PO2, PO4	C1, C4, C5	Lectures Discussions Homework	Assignment Incourse Final exam

	requirements and standards for systems protection				

14.83.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓	✓	✓	✓	✓	✓			✓	✓	✓					✓	✓		✓	

14.83.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-3	High Voltage DC Generation: DC Generation, Rectifier Circuits, Voltage Multipliers, Van de Graaf and Electrostatic Generators, Applications.	CO1
2-3	4-6	High Voltage DC Transmission Grids: DC Grid Planning, Topology, Power- Transfer Security, DC Grids with Line-Commutated Converters,	CO1
4	7-8	DC Grids with Voltage Source Converters, DC Grid Control, DC Grid Fault Management and DC Circuit Breakers.	CO1
5-6	9-11	High Voltage AC Generation: AC Generation, Cascaded Transformers and Tesla Coils,	CO1
6-7	12-13	Impulse Voltage: Shapes, Mathematical Analysis, Codes and Standards, Single and Multi-Stage Impulse Generators, Tripping and Control of Impulse Generators.	CO1
7-8	14-16	High Voltage Protection: Breakdown in Gas, Liquid and Solid Dielectric Materials,	CO1, CO3
9	17-18	Corona phenomena in high voltage	CO1
10-11	19-22	High Voltage Measurements and Testing: IEC and IEEE Standards, Sphere Gap, Electrostatic Voltmeter, Potential Divider, Schering Bridge, Megaohm Meter,	CO1, CO2, CO3
12	23-24	HV Current and Voltage Transducers: Contact and Noncontact.	CO1, CO3
13-14	25-28	Over-Voltage Phenomenon and Insulation Coordination, Lightning and Switching Surges, Basic Insulation Level, Surge Diverters and Arresters.	CO4, CO5

14.83.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.83.8 Text Books and Reference Books

1) High Voltage Engineering: Fundamentals, 2nd Edition, E. Kuffel, W.S. Zaengl and J. Kuffel, Newnes Publication.

2) High Voltage Engineering, Farouk A.M. Rizk and Giao N. Trinh, CRC Press.

3) High Voltage Engineering, Andreas Küchler, Springer.

4) High-Voltage Direct-Current Transmission, Dragan Jovcic and Khaled Ahmed, Wiley.

5) High Voltage and Electrical Insulation Engineering, Ravindra Arora and Wolfgang Mosch, IEEE Press.

6) HVDC and FACTS Controllers, Vijay K. Sood, Springer.

14.84 Internet of Things

14.84.1 Introduction of the Course

Course Code and Title: 0714-EEE-4265: Internet of Things.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the principles, technologies, and applications that define the IoT ecosystem. As IoT continues to revolutionize industries by enabling the interconnection of devices and systems, this course covers essential concepts of physical and logical design, and the enabling technologies that drive IoT innovation. With a focus on both theoretical knowledge and practical skills, graduates will be well-equipped to design, implement, and manage IoT solutions across various domains such as smart cities, healthcare, industrial automation, and more.

Prerequisites (if any): No prerequisite.

14.84.2 Course Objectives

The students are expected to

1) Gain an in-depth understanding of the fundamental concepts, history, and evolution of the Internet of Things.

2) Understand the physical and logical design aspects of IoT for implementing IoT applications.

3) Explore the integration and programming of IoT physical devices and endpoints.

4) Analyze and apply IoT solutions across various domain-specific applications such as smart grids, connected vehicles, and industrial IoT.

14.84.3 Course Content

Introduction and Concepts: Introduction to Internet of Things, Introduction to Arduino Programming, Brief History and evolution of IoT, Physical Design of IoT, Logical Design of IoT, IoT Enabling Technologies, IoT Levels.

Developing IoTs and Logical Design using Python: Introduction, IoT Design Methodology, Installing Python, Python Data Types and Data Structures, Control Flow, Functions, Modules, Packages, File Handling, Date/ Time Operations, Classes, Python Packages.

IoT Physical Devices and Endpoints: IoT Devices, Exemplary Device, Board, and Linux on Raspberry Pi, Interfaces, and Programming and IoT Devices.

Domain Specific IoTs: Cloud Computing, Sensor-Cloud, Connected Vehicles, Smart Grid, Industrial IoT, Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Life Style, Cloud Computing.

14.84.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Demonstrate an understanding of the fundamental concepts, history, and evolution of the Internet of Things	PO1, PO7	C1, C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Understand and apply the physical and logical design aspects of IoT in the development of IoT applications	PO3, PO5, PO8, PO10, PO12	C3, C4, C6, A4, P5	Lectures Discussions Exercise	Assignment Final Exam
CO3	Integrate and program IoT physical devices and endpoints	PO1, PO3, PO5	C3, P4, P7	Lectures Discussions Exercise	Assignment Final Exam

	using appropriate platforms				

14.84.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
✓		✓		✓	✓	✓		✓	✓					✓	✓	✓	✓		✓

14.84.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1-2	1-4	Introduction to Internet of Things, Brief History and Evolution of IoT Introduction to Arduino Programming, Physical Design of IoT	CO1, CO2
3-4	5-8	Logical Design of IoT, IoT Enabling Technologies, IoT Levels Introduction to IoT Design Methodology, Installing Python	CO1, CO2
5-7	9-14	Python Data Types and Data Structures, Control Flow Python Functions, Modules, Packages File Handling, Date/Time Operations in Python	CO2
8	15-16	Classes in Python, Python Packages	CO2
9-10	17-20	IoT Devices, Exemplary Device, Board, and Linux on Raspberry Pi Interfaces and Programming IoT Devices	CO3
11-13	21-26	Domain Specific IoTs: Cloud Computing, Sensor-Cloud, Connected Vehicles, Smart Grid Industrial IoT, Home Automation, Smart Cities	CO2, CO3
14	27-28	Domain Specific IoTs: Environment, Energy, Retail, Logistics Agriculture, Industry, Health, and Lifestyle	CO2, CO3

14.84.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.84.8 Text Books and Reference Books

1) Internet of Things: A Hands-On- Approach, Vijay Madisetti and Arshdeep Bahga, Orient Blackswan.

2) Designing the Internet of Things, 1st Edition, Adrian McEwen, Wiley.

3) Internet of Things: Architectures, Protocols and Standards, 1st Edition, by Simone Cirani, Gianluigi Ferrari, Marco Picone and Luca Veltri, Wiley.

14.85 Neural Network and Fuzzy Systems

14.85.1 Introduction of the Course

Course Code and Title: 0714-EEE-4267: Neural Network and Fuzzy Systems.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: The main objective of this course is to provide the student with the basic understanding of neural networks, fuzzy logic fundamentals and their applications in engineering design and implementation. Several neural networks, deep learning models, convolutional neural networks and their training algorithms will be discussed with mathematical formulation, implementation and applications. Students will also learn Fuzzy logic, Fuzzy set theory and Fuzzy inference mechanisms with implementation for practical designs. Moreover, Boltzmann Machines and Support vector machine will also be discussed. Some case studies on design and implementation of Robotic Arm Control, Unmanned Air-vehicle Control, Smart Car Control and Household Appliances will be demonstrated.

Prerequisites (if any): No prerequisite.

14.85.2 Course Objectives

The students are expected to

1) Gain fundamental knowledge of neural networks, fuzzy logic, support vector machine and learning algorithms.

2) Examine the structure, functionality and performance of neural networks and their learning/training algorithms and fuzzy inference systems.

3) Develop programming proficiency to develop and implement neural networks and fuzzy systems.

4) Explore advanced AI concepts such as deep learning, convolutional network, recurrent network, classification of linear/nonlinear systems and knowledge-based systems.

5) Apply neural networks and fuzzy systems in designing and implementing different real world complex engineering systems.

14.85.3 Course Content

Neural Networks: Artificial Neural Networks, Mcculloch-Pitts Networks, Perceptrons, Regression and Least Mean Square Algorithm, Multilayer Perceptrons, Radial-Basis Function Networks, Support Vector Machines, Unsupervised Learning and Self-Organization, Boltzmann Machines and Deep Networks Convolutional Networks, Recurrent Networks.

Fuzzy Logic: Introduction, Fuzzy Logic, Fuzzy Sets, Membership Functions, Features of MFs, Operations on Fuzzy Sets, Linguistic Variables, Linguistic Hedges, Fuzzy Relations, Fuzzy if–then Rules, Fuzzification, Defuzzification, Inference Mechanism: Mamdani Fuzzy Inference, Sugeno Fuzzy Inference, Sukamoto Fuzzy Inference, Defuzzification Methods, Properties of Defuzzification, Analysis of Defuzzification Methods.

Fuzzy Systems and Applications: Introduction, Fuzzy Modelling, Fuzzy Control, Design of Fuzzy Controller: Types of Fuzzy Controllers, PD/PI/PID-Like Fuzzy Logic Controllers, Modular Fuzzy Controller, Case Studies: Robotic Arm Control, Unmanned Air-vehicle Control, Smart Car Control, Household Appliances.

14.85.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Develop a basic understanding of neural networks, fuzzy logic, support vector machine and learning algorithms	PO1	C1, C2	Lectures Discussions Handouts	Assignment Presentation Final Exam
CO2	Analyze the architecture and performance of neural networks and their learning/training algorithms and fuzzy inference systems	PO2, PO3	C4, C5	Lectures Discussions Handouts	Incourse Final Exam
CO3	Acquire skills in programming language used to develop and implement neural networks and fuzzy systems	PO3, PO5	C3, C6	Lectures Discussions Handouts Exercise	Assignment Presentation Final Exam

CO4	Understanding deep learning, convolutional network, recurrent network, classification of linear/nonlinear systems and concept of expert or knowledge-based systems	PO2, PO4	C1, C3	Lectures Discussions Handouts Exercise	Incourse Final Exam
CO5	Design and Implementation of different real world complex engineering systems	PO3, PO5	C4, C6	Lectures Discussions Handouts Exercise	Presentation Incourse Final Exam

14.85.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓

14.85.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-2	Neural Networks: Artificial Neural Networks, Mcculloch-Pitts Networks	CO1
2	3-4	Perceptrons, Regression and Least Mean Square Algorithm	CO1, CO2
3	5-6	Multilayer Perceptrons	CO2
4	7-8	Radial-Basis Function Networks	CO2, CO3
5	9-10	Support Vector Machines	CO1, CO3
6	11-12	Unsupervised Learning and Self-Organization, Boltzmann Machines and	CO2
7	13-14	Deep Networks, Convolutional Networks,	CO4
8	15-16	Recurrent Networks	CO4

9	17-18	Fuzzy Logic: Introduction, Fuzzy Logic, Fuzzy Sets, Membership Functions, Features of MFs, Operations on Fuzzy Sets	CO1, CO2
10	19-20	Linguistic Variables, Linguistic Hedges, Fuzzy Relations, Fuzzy if–then Rules, Fuzzification, Defuzzification, Inference Mechanism: Mamdani Fuzzy Inference,	CO2
11	21-22	Sugeno Fuzzy Inference, Sukamoto Fuzzy Inference, Defuzzification Methods, Properties of Defuzzification, Analysis of Defuzzification Methods.	CO3
12	23-24	Fuzzy Systems and Applications: Introduction, Fuzzy Modelling, Fuzzy Control, Design of Fuzzy Controller: Types of Fuzzy Controllers, PD/PI/PID-Like Fuzzy Logic Controllers,	CO3
13	25-26	Modular Fuzzy Controller, Case Studies: Robotic Arm Control, Unmanned Air-vehicle Control,	CO5
14	27-28	Case Studies: Smart Car Control, Household Appliances.	CO5

14.85.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.85.8 Text Books and Reference Books

1) Neural Networks and Learning Machines, 3rd Edition, Simon Haykin. Pearson.

2) Deep learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville. MIT Press.

3) Computational Intelligence: Synergies of Fuzzy Logic, Neural Networks and Evolutionary Computing, 1st Edition, N. Siddique N and H.Adeli, John Wiley & Sons.

4) Intelligent Control: A Hybrid Approach Based on Fuzzy Logic, Neural Networks and Genetic Algorithms, N. Siddique, Springer.

14.86 Robotics and Embedded Systems

14.86.1 Introduction of the Course

Course Code and Title: 0714-EEE-4269: Robotics and Embedded Systems.

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week.

Rationale of the Course: This course is designed to provide students with a comprehensive understanding of the principles and technologies that underpin modern robotic and embedded systems. This course equips students with the necessary skills to design, analyze, and implement robotic systems and embedded platforms. Through this course, students will gain insights into the mechanical design, kinematics, dynamics, and control of robots, as well as the intricacies of embedded system design, enabling them to tackle complex engineering challenges in various industrial and research settings.

Prerequisites (if any): 0541-MAT-1107: Linear Algebra and Numerical Analysis, 0713-EEE-2107: Electromechanical Energy Conversion I, 0713-EEE-2203: Electromechanical Energy Conversion II, 0715-MEC-2205: Fundamentals of Mechanical Engineering.

14.86.2 Course Objectives

The students are expected to

1) Understand the fundamental concepts and classifications of robots, including their applications and basic components.

2) Analyze the mechanical design aspects of robots, including kinematic chains, degrees of freedom, and robot end effectors.

3) Develop proficiency in spatial descriptions and transformations, manipulator kinematics, and dynamics for the effective control of robotic systems.

4) Gain a solid foundation in embedded system design, including specifications, hardware platforms, peripherals, and interfacing with external sensors and actuators.

14.86.3 Course Content

Introduction: Definition and Classification of Robots, Laws of Robotics, Applications of Robots, Basic Components of Robot Systems.

Mechanical Design of Robots: Links and Joints, Kinematic Chain, Mechanisms and Machines, Degrees of Freedom, Robot End Effectors.

Spatial Descriptions and Transformations: Description of Position, Orientation and Frames, Homogeneous Transformations.

Manipulator Kinematics: Link Parameters and Link Co-ordinate Systems, D-H Homogeneous Transformation Matrices, Forward and Inverse Kinematics of Serial Manipulators.

Manipulator Dynamics: Recursive Newton-Euler Formulation of Serial Manipulator, Lagrangian Formulation of Serial Manipulator.

Robot Control Architecture: Trajectory Planning, Control of Manipulators, Motor Control, Robot Sensors, Low Level Robot Vision, Robot Programming.

Embedded System: Overview of the Design Flow, Embedded Systems Specifications and Modeling, Embedded Hardware Platforms and Peripherals, Interfacing to the External World Through Sensors and Actuators.

14.86.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1	Explain the fundamental concepts, classifications, applications, and basic components of robotic systems	PO1	C2	Lectures Discussions Handouts	Incourse Final Exam
CO2	Analyze and design the mechanical aspects of robots, including kinematic chains, degrees of freedom, and robot end effectors	PO2, PO3	C4, C6	Lectures Discussions Exercise	Assignment Final Exam
CO3	Apply principles of spatial descriptions, transformations, manipulator kinematics, and dynamics to solve problems related to robotic system control	PO1, PO2	C3	Lectures Discussions Exercise	Assignment Final Exam
CO4	Design and implement embedded systems, including hardware platforms, peripherals, and interfacing with external sensors and actuators for real-world applications	PO3, PO5	C6, P7	Lectures Discussions	Incourse Final Exam Presentation

14.86.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
√			√	√	√			√				√	√	√			√		√

14.86.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs
1	1-3	Introduction: Definition and Classification of Robots, Laws of Robotics, Applications of Robots, Basic Components of Robot Systems	CO1
2-3	4-6	Links and Joints, Kinematic Chain, Mechanisms and Machines, Degrees of Freedom, Robot End Effectors	CO2
4-5	7-10	Description of Position, Orientation and Frames, Homogeneous Transformations, Link Parameters and Link Co-ordinate Systems, D-H Homogeneous Transformation Matrices	CO3
6	11-12	Forward Kinematics of Serial Manipulators, Inverse Kinematics of Serial Manipulators	CO3
7-8	13-16	Recursive Newton-Euler Formulation of Serial Manipulator, Lagrangian Formulation of Serial Manipulator, Trajectory Planning	CO3
9-11	17-21	Control of Manipulators, Motor Control, Robot Sensors, Low-Level Robot Vision, Robot Programming	CO3
11-12	22-24	Overview of the Design Flow in Embedded Systems, Embedded Systems Specifications and Modeling, Embedded Hardware Platforms and Peripherals	CO4
13-14	25-28	Interfacing to the External World Through Sensors and Actuators, Design and Implementation Project: Concept Development, Design and Implementation Project: System Integration and Testing	CO4

14.86.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation: There will be a minimum 1 Assignment and/or presentation; if 2 or more assignment or presentation are taken then their average will be considered in final evaluation.

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.86.8 Text Books and Reference Books

1) Modeling and Control of Robot Manipulator, Sciavicco and Siciliano, McGraw-Hill.

2) Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson Prentice Hall.

3) Robot Analysis, 1st Edition, Lung-Wen Tsai, Wiley-Interscience

4) The 8051 Microcontroller and Embedded System, 2nd Edition, Muhammad Ali Majidi, Pearson.

15. Detailed CO-PO Mapping of All Offered Courses

15.1 Detailed CO-PO Mapping of All Offered Compulsory Courses

Year & Semester	Courses	COs	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
1st Year 1st Semester	0713-EEE-1101	CO1	✓											
		CO2		✓										
		CO3			✓									
		CO4			✓									
	0533-PHY-1103	CO1	✓											
		CO2		✓	✓									
		CO3			✓									
		CO4				✓	✓							
	0541-MAT-1105	CO1		✓										
		CO2	✓	✓										
		CO3	✓	✓										
		CO4		✓		✓								
	0541-MAT-1107	CO1	✓	✓										
		CO2	✓	✓	✓									
		CO3	✓	✓	✓									
		CO4	✓	✓		✓								
	0231-GED-1109	CO1										✓		✓
		CO2										✓	✓	✓
		CO3									✓	✓		✓
		CO4									✓	✓		✓
	0713-EEE-1102	CO1	✓	✓										
		CO2	✓		✓									
		CO3		✓	✓	✓								
	0732-CIV-1112	CO1	✓				✓							
		CO2			✓		✓							

		CO3			✓		✓							
		CO4		✓									✓	
	Summary (Y1S1)		✓	✓	✓	✓	✓				✓	✓	✓	✓
1st Year 2nd Semester	0533-PHY-1201	CO1	✓	✓										
		CO2		✓		✓								
		CO3	✓	✓		✓								✓
	0533-PHY-1203	CO1	✓											
		CO2		✓										
		CO3			✓									
	0613-CSE-1205	CO1	✓	✓										
		CO2		✓	✓									
		CO3		✓	✓	✓								
		CO4			✓		✓				✓			
	0531-CHE-1207	CO1	✓	✓										
		CO2	✓		✓									
		CO3		✓	✓									
		CO4	✓	✓			✓							
		CO5	✓	✓	✓									
	0541-MAT-1209	CO1	✓	✓		✓								
		CO2	✓	✓		✓								
		CO3	✓	✓										✓
		CO4	✓	✓		✓	✓							
	0533-PHY-1204	CO1	✓				✓							
		CO2	✓	✓			✓							
		CO3	✓	✓		✓								
		CO4		✓								✓		✓
	0613-CSE-1206	CO1	✓	✓			✓				✓	✓		
		CO2	✓	✓	✓	✓	✓							✓
		CO3	✓	✓	✓		✓					✓	✓	
	0531-CHE-1208	CO1	✓	✓										
		CO2	✓		✓									
		CO3					✓							
		CO4	✓	✓		✓								
	Summary (Y1S2)		✓	✓	✓	✓	✓				✓	✓	✓	✓
2nd Year 1st Semester	0714-EEE-2101	CO1		✓										
		CO2		✓										
		CO3		✓										
		CO4	✓											
	0714-EEE-2103	CO1	✓	✓										
		CO2			✓		✓							
		CO3	✓		✓									
		CO4	✓		✓		✓							
	0714-EEE-2105	CO1	✓	✓										
		CO2	✓	✓										
		CO3		✓		✓								
		CO4			✓		✓		✓					
	0713-EEE-2107	CO1	✓											
		CO2		✓										

		CO3			✓									
		CO4				✓								
	0714-EEE-2109	CO1	✓											
		CO2	✓	✓										
		CO3		✓	✓									
		CO4			✓	✓								
	0541-MAT-2111	CO1	✓	✓										
		CO2	✓	✓		✓								
		CO3	✓	✓	✓		✓							
	0714-EEE-2102	CO1		✓	✓									
		CO2		✓	✓									
		CO3	✓											
		CO4			✓		✓				✓			
	0714-EEE-2104	CO1	✓				✓							
		CO2	✓	✓										
		CO3	✓	✓										
		CO4	✓	✓										
		CO5								✓	✓	✓		✓
	Summary (Y2S1)		✓	✓	✓	✓	✓		✓	✓	✓	✓		✓
2nd Year 2nd Semester	0714-EEE-2201	CO1	✓											
		CO2		✓										
		CO3			✓									
		CO4				✓								
	0713-EEE-2203	CO1	✓											
		CO2		✓										
		CO3		✓		✓								
		CO4				✓								
		CO5			✓									
	0715-MEC-2205	CO1	✓	✓										
		CO2			✓	✓								
		CO3	✓		✓									
		CO4	✓	✓		✓								
		CO5		✓	✓		✓							
	0542-STA-2207	CO1	✓											
		CO2	✓	✓		✓								
		CO3		✓		✓	✓							
		CO4			✓	✓	✓							
	0311-GED-2209	CO1		✓									✓	
		CO2		✓									✓	
		CO3		✓		✓							✓	
		CO4		✓		✓			✓				✓	
		CO5		✓		✓			✓				✓	✓
	0714-EEE-2202	CO1	✓	✓										
		CO2		✓	✓									
		CO3	✓		✓	✓								
	0713-EEE-2204	CO1	✓											
		CO2			✓									
		CO3				✓								

		CO4		✓										
	0715-MEC-2206	CO1	✓											
		CO2		✓										
		CO3			✓									
		CO4									✓			
		CO5										✓		
	Summary (Y2S2)		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
3rd Year 1st Semester	0714-EEE-3101	CO1	✓	✓	✓									
		CO2	✓	✓	✓	✓								
		CO3	✓		✓		✓				✓			
	0714-EEE-3103	CO1	✓											
		CO2		✓										
		CO3			✓									
		CO4			✓									
	0714-EEE-3105	CO1	✓											
		CO2	✓	✓										
		CO3	✓											
		CO4	✓											
		CO5			✓									
	0714-EEE-3107	CO1	✓	✓										
		CO2		✓			✓							
		CO3			✓	✓								
		CO4	✓											
		CO5				✓								
	0714-EEE-3109	CO1	✓											
		CO2		✓	✓									
		CO3			✓		✓							
		CO4				✓								
	0413-IPE-3111	CO1									✓			
		CO2			✓									
		CO3		✓										
		CO4											✓	
	0714-EEE-3104	CO1		✓										
		CO2		✓										
		CO3											✓	
		CO4										✓		
	0714-EEE-3106	CO1	✓											
		CO2					✓							
		CO3			✓									
		CO4			✓									
		CO5		✓		✓								
	Summary (Y3S1)		✓	✓	✓	✓	✓				✓	✓	✓	
3rd Year 2nd Semester	0713-EEE-3201	CO1	✓											
		CO2			✓									
		CO3					✓							
		CO4		✓										
		CO5				✓								
		CO1	✓	✓	✓									

	0714-EEE-3203	CO2		✓		✓								
		CO3		✓										
		CO4			✓		✓				✓			
	0714-EEE-3205	CO1	✓	✓										
		CO2	✓	✓		✓								
		CO3	✓	✓		✓								
		CO4	✓	✓										
	0714-EEE-3207	CO1	✓											
		CO2	✓											
		CO3		✓		✓								
		CO4							✓					
	0714-EEE-3209	CO1	✓											
		CO2	✓	✓										
		CO3	✓		✓									
		CO4		✓										
	0411-GED-3211	CO1	✓	✓								✓		
		CO2		✓		✓							✓	
		CO3	✓	✓			✓							
		CO4			✓								✓	✓
		CO5					✓					✓		✓
	0713-EEE-3202	CO1	✓		✓	✓	✓							
		CO2	✓	✓	✓	✓	✓							
		CO3	✓	✓	✓		✓							
		CO4	✓		✓	✓								
		CO5											✓	
	0714-EEE-3204	CO1	✓	✓			✓							
		CO2		✓		✓								
		CO3	✓	✓			✓							
		CO4			✓		✓							
		CO5									✓	✓		✓
	0713-EEE-3214	CO1	✓											
		CO2	✓											
		CO3		✓				✓						
		CO4			✓									
	Summary (Y3S2)		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
4th Year 1st Semester	0714-EEE-4101	CO1	✓											
		CO2		✓	✓									
		CO3				✓			✓					
		CO4	✓										✓	
	0223-GED-4103	CO1	✓											
		CO2	✓									✓		
		CO3									✓	✓		
		CO4	✓											
	0714-EEE-4102	CO1			✓									
		CO2		✓	✓									
		CO3			✓								✓	
		CO4										✓		
		CO1										✓		

	0714-EEE-4100	CO2		✓										
		CO3									✓		✓	
		CO4						✓		✓				
	Summary (Y4S1)		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	
4th Year 2nd Semester	0714-EEE-4201	CO1	✓	✓										
		CO2	✓		✓									
		CO3		✓	✓									
		CO4			✓									
		CO5	✓											
	0713-EEE-4271	CO1	✓						✓					
		CO2		✓		✓								
		CO3			✓		✓		✓					
		CO4							✓					✓
	0714-EEE-4202	CO1			✓									
		CO2		✓										
		CO3	✓	✓										
		CO4			✓									
	0713-EEE-4272	CO1	✓				✓							
		CO2		✓		✓								
		CO3			✓		✓							
		CO4				✓			✓					✓
	0714-EEE-4200	CO1										✓		
		CO2	✓											
		CO3	✓			✓								
		CO4						✓		✓				
		CO5									✓		✓	
	Summary (Y4S2)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summary (Compulsory Courses)			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

15.2 Detailed CO-PO Mapping of All Offered Optional Courses

Year & Semester	Courses	COs	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
4th Year 1st Semester	0714-EEE-4131	CO1	✓	✓										
		CO2	✓	✓	✓									
		CO3												✓
	0714-EEE-4133	CO1	✓	✓										
		CO2			✓		✓							
		CO3				✓				✓				
		CO4	✓		✓		✓							
	0714-EEE-4134	CO1	✓		✓		✓							
		CO2	✓		✓		✓							
		CO3	✓		✓		✓				✓			
	0714-EEE-4141	CO1	✓	✓										
		CO2				✓		✓						
		CO3	✓	✓			✓							
		CO4	✓		✓		✓							
		CO5	✓	✓			✓		✓					
		CO1	✓	✓	✓									

	0714-EEE-4143	CO2		✓		✓								
		CO3	✓	✓			✓							
		CO4			✓		✓				✓			
	0714-EEE-4144	CO1	✓	✓										
		CO2			✓		✓							
		CO3		✓		✓	✓							
		CO4		✓	✓									
		CO5									✓	✓		✓
	0713-EEE-4151	CO1	✓	✓										
		CO2			✓									
		CO3	✓			✓	✓							
		CO4	✓											
		CO5			✓	✓	✓							
	0713-EEE-4153	CO1	✓	✓										
		CO2		✓	✓									
		CO3			✓		✓	✓						
		CO4		✓			✓							
	0713-EEE-4154	CO1					✓							
		CO2		✓			✓							
		CO3		✓			✓							
		CO4		✓			✓							
		CO5					✓							
	0612-CSE-4161	CO1			✓									
		CO2					✓							
		CO3	✓											
		CO4			✓									
	0612-CSE-4163	CO1	✓											
		CO2		✓										
		CO3			✓									
		CO4				✓								
	0612-CSE-4164	CO1	✓		✓									
		CO2		✓		✓								
		CO3				✓	✓							
		CO4					✓							
		CO5						✓						
	Summary (Y4S1)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
4th Year 2nd Semester	0714-EEE-4231	CO1	✓	✓	✓									
		CO2	✓	✓		✓								
		CO3		✓		✓								
		CO4	✓	✓										
		CO5	✓	✓			✓							✓
	0714-EEE-4233	CO1	✓											
		CO2	✓	✓										
		CO3				✓								
		CO4	✓											
	0714-EEE-4241	CO1	✓											
		CO2	✓	✓			✓							
		CO3		✓		✓	✓							

		CO4	✓		✓									
		CO5	✓				✓		✓					
	0714-EEE-4243	CO1	✓				✓							
		CO2		✓	✓		✓							
		CO3		✓		✓								
		CO4			✓		✓		✓					
	0713-EEE-4251	CO1	✓	✓										
		CO2				✓								
		CO3			✓									
		CO4					✓							
		CO5				✓								
	0713-EEE-4253	CO1	✓	✓			✓							
		CO2			✓				✓				✓	
		CO3						✓	✓					✓
	0714-EEE-4261	CO1	✓				✓							
		CO2		✓										
		CO3				✓								
		CO4		✓	✓									
		CO5			✓		✓							
	0612-CSE-4263	CO1	✓	✓										
		CO2	✓	✓	✓									
		CO3	✓				✓							
		CO4	✓	✓	✓									
	Summary (Y4S2)		✓	✓	✓	✓	✓		✓				✓	✓
Summary (Optional Courses)			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summary (Compulsory & Optional Courses)			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

16. Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities of All Offered Courses

16.1 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities of All Offered Compulsory Courses

Year & Semester	Courses	K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
1st Year 1st Semester	0713-EEE-1101	✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓
	0533-PHY-1103	✓	✓	✓		✓				✓	✓								✓		✓
	0541-MAT-1105		✓	✓	✓					✓		✓	✓						✓	✓	✓
	0541-MAT-1107	✓	✓	✓	✓	✓			✓	✓		✓		✓			✓	✓	✓		
	0231-GED-1109							✓					✓	✓	✓				✓	✓	
	0713-EEE-1102	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		
	0732-CIV-1112					✓	✓			✓	✓		✓				✓		✓		✓
Summary (Y1S1)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
1st Year 2nd Semester	0533-PHY-1201	✓	✓	✓	✓				✓	✓	✓	✓						✓	✓		
	0533-PHY-1203	✓		✓	✓	✓	✓			✓	✓		✓				✓	✓	✓		
	0613-CSE-1205	✓	✓			✓				✓		✓		✓	✓				✓		✓
	0531-CHE-1207	✓		✓	✓					✓		✓					✓		✓		
	0541-MAT-1209	✓	✓	✓	✓					✓	✓	✓	✓					✓	✓		✓

	0533-PHY-1204	✓	✓	✓						✓							✓				
	0613-CSE-1206	✓	✓	✓	✓		✓			✓	✓			✓			✓	✓	✓	✓	✓
	0531-CHE-1208	✓		✓	✓		✓			✓				✓			✓				
Summary (Y1S2)		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
2nd Year 1st Semester	0714-EEE-2101	✓	✓	✓	✓	✓				✓	✓	✓									
	0714-EEE-2103	✓	✓	✓	✓	✓	✓			✓	✓	✓				✓		✓	✓		✓
	0714-EEE-2105	✓	✓	✓						✓			✓								
	0713-EEE-2107	✓	✓	✓		✓	✓			✓	✓						✓	✓			
	0714-EEE-2109	✓	✓	✓	✓	✓				✓	✓		✓				✓			✓	
	0541-MAT-2111	✓	✓	✓						✓	✓	✓				✓		✓		✓	✓
	0714-EEE-2102	✓	✓	✓		✓	✓			✓	✓						✓	✓		✓	
	0714-EEE-2104	✓	✓	✓	✓	✓	✓				✓	✓			✓				✓		✓
Summary (Y2S1)		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2nd Year 2nd Semester	0714-EEE-2201	✓		✓	✓	✓	✓			✓	✓					✓	✓	✓	✓		
	0713-EEE-2203	✓	✓	✓		✓	✓			✓	✓						✓	✓			
	0715-MEC-2205	✓	✓	✓	✓	✓	✓					✓			✓		✓	✓	✓		✓
	0542-STA-2207	✓	✓	✓						✓		✓	✓				✓			✓	✓
	0311-GED-2209					✓		✓		✓	✓				✓		✓	✓			✓
	0714-EEE-2202	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		
	0713-EEE-2204	✓	✓				✓			✓	✓						✓	✓			
	0715-MEC-2206	✓	✓	✓	✓	✓				✓								✓	✓	✓	
Summary (Y2S2)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
3rd Year 1st Semester	0714-EEE-3101	✓		✓	✓	✓			✓	✓	✓	✓	✓					✓	✓		✓
	0714-EEE-3103			✓	✓		✓			✓	✓					✓	✓	✓	✓		✓
	0714-EEE-3105	✓	✓	✓	✓					✓	✓						✓	✓			
	0714-EEE-3107	✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓
	0714-EEE-3109	✓			✓	✓	✓		✓	✓	✓	✓				✓		✓	✓		✓
	0413-IPE-3111	✓	✓	✓	✓			✓	✓	✓	✓								✓	✓	✓
	0714-EEE-3104			✓			✓	✓		✓	✓		✓		✓		✓	✓		✓	
	0714-EEE-3106		✓	✓		✓	✓			✓	✓		✓			✓	✓	✓			✓
Summary (Y3S1)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
3rd Year 2nd Semester	0713-EEE-3201	✓	✓	✓	✓	✓				✓	✓	✓					✓	✓	✓		
	0714-EEE-3203		✓	✓	✓	✓	✓			✓		✓				✓	✓		✓		✓
	0714-EEE-3205	✓		✓	✓					✓		✓					✓				✓
	0714-EEE-3207	✓	✓	✓	✓			✓	✓	✓	✓						✓	✓			
	0714-EEE-3209	✓	✓	✓	✓					✓	✓						✓	✓			
	0411-GED-3211		✓					✓						✓	✓		✓			✓	
	0713-EEE-3202	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		
	0714-EEE-3204	✓	✓	✓		✓				✓				✓		✓	✓		✓		
	0713-EEE-3214	✓	✓	✓				✓		✓							✓	✓			
Summary (Y3S2)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4th Year 1st Semester	0714-EEE-4101	✓	✓	✓			✓	✓		✓	✓						✓	✓	✓		
	0223-GED-4103							✓		✓	✓						✓				
	0714-EEE-4102		✓			✓	✓			✓	✓	✓				✓	✓	✓	✓		✓
	0714-EEE-4100	✓		✓				✓	✓	✓	✓	✓				✓	✓	✓	✓		✓
Summary (Y4S1)		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓
4th Year 2nd Semester	0714-EEE-4201	✓	✓	✓						✓	✓	✓	✓				✓	✓			
	0713-EEE-4271	✓				✓	✓	✓						✓	✓	✓	✓				

	0714-EEE-4202	✓	✓	✓						✓							✓				
	0713-EEE-4272	✓			✓	✓	✓	✓				✓	✓		✓				✓	✓	
	0714-EEE-4200		✓				✓	✓		✓	✓	✓				✓	✓	✓	✓		✓
Summary (Y4S2)		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summary (Compulsory Courses)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

16.2 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities of All Offered Optional Courses

Year & Semester	Courses	K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5
4th Year 1st Semester	0714-EEE-4131	✓	✓	✓	✓	✓						✓			✓					✓	
	0714-EEE-4133	✓			✓	✓	✓		✓	✓				✓	✓	✓			✓		✓
	0714-EEE-4134		✓	✓	✓	✓	✓			✓		✓	✓						✓		✓
	0714-EEE-4141	✓			✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	
	0714-EEE-4143	✓	✓	✓	✓	✓	✓			✓				✓	✓	✓	✓				
	0714-EEE-4144			✓		✓	✓		✓	✓				✓		✓		✓	✓		
	0713-EEE-4151	✓	✓	✓	✓	✓	✓			✓	✓	✓						✓		✓	
	0713-EEE-4153	✓		✓	✓	✓	✓			✓		✓	✓		✓	✓	✓	✓		✓	
	0713-EEE-4154					✓	✓	✓		✓		✓	✓				✓	✓			
	0612-CSE-4161	✓		✓			✓			✓	✓	✓					✓	✓	✓		
	0612-CSE-4163				✓	✓	✓			✓	✓			✓			✓	✓		✓	
	0612-CSE-4164		✓	✓	✓		✓			✓	✓		✓		✓		✓	✓		✓	
Summary (Y4S1)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4th Year 2nd Semester	0714-EEE-4231	✓	✓	✓	✓					✓	✓	✓						✓	✓		✓
	0714-EEE-4233	✓	✓	✓	✓					✓								✓	✓		✓
	0714-EEE-4241	✓		✓	✓	✓	✓			✓		✓			✓	✓	✓		✓	✓	
	0714-EEE-4243			✓	✓	✓	✓			✓		✓			✓	✓	✓	✓	✓	✓	
	0713-EEE-4251	✓	✓	✓	✓	✓				✓	✓	✓					✓	✓	✓		
	0713-EEE-4253	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓			
	0714-EEE-4261	✓	✓	✓	✓	✓	✓			✓	✓								✓	✓	✓
	0612-CSE-4263	✓	✓		✓	✓	✓			✓		✓		✓					✓	✓	✓
Summary (Y4S2)		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summary (Optional Courses)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summary (Compulsory & Optional Courses)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Appendix

A. Course Code Policy

Every course has a unique course code. First four digits follow the Common Classification System for Subjects as defined by the BNQF. EEE Dept., DU uses the next three letters to identify specific field or discipline of the courses. Last four digits are assigned by the department, as shown in the following table.

<table>
<tr><th colspan="2">Common Classification System for Subjects (BNQF)</th><th colspan="4">EEE Dept., DU</th></tr>
<tr><th>1234</th><th>Detailed field</th><th>8</th><th>9</th><th>10</th><th>11</th></tr>
<tr><td>0223</td><td>Philosophy and ethics</td><td rowspan="16">Year</td><td rowspan="16">Semester</td><td rowspan="16">0, 1, 2 for Core Courses
3 for Electronics Stream
4 for Communications and Signal Processing Stream
5 for Power Stream
6 for Computer Stream
7 for Interdisciplinary Courses</td><td rowspan="16">odd for theoretical course
even for laboratory or sessional course</td></tr>
<tr><td>0231</td><td>Language acquisition</td></tr>
<tr><td>0311</td><td>Economics</td></tr>
<tr><td>0313</td><td>Psychology</td></tr>
<tr><td>0411</td><td>Accounting and taxation</td></tr>
<tr><td>0413</td><td>Management and administration</td></tr>
<tr><td>0531</td><td>Chemistry</td></tr>
<tr><td>0533</td><td>Physics</td></tr>
<tr><td>0541</td><td>Mathematics</td></tr>
<tr><td>0542</td><td>Statistics</td></tr>
<tr><td>0612</td><td>Database and network design and administration</td></tr>
<tr><td>0613</td><td>Software and applications, development and analysis</td></tr>
<tr><td>0713</td><td>Electricity and energy</td></tr>
<tr><td>0714</td><td>Electronics and automation</td></tr>
<tr><td>0715</td><td>Mechanics and metal trades</td></tr>
<tr><td>0732</td><td>Building and civil engineering</td></tr>
</table>

Field or discipline of the course is identified as

EEE : Electrical and Electronic Engineering
PHY : Physics
MEC : Mechanical Engineering
CSE : Computer Science and Engineering
IPE : Industrial and Production Engineering
CIV : Civil Engineering
CHE : Chemistry
MAT : Mathematics
STA : Statistics
GED : General Education (Humanities and Social Science).

B. Domains and Taxonomy Level

Taxonomy	Level
C	**Cognitive**
C1	Knowledge
C2	Comprehension
C3	Application
C4	Analysis
C5	Synthesis
C6	Evaluation
A	**Affective**
A1	Receiving
A2	Responding
A3	Valuing
A4	Organizing
A5	Characterizing
P	**Psychomotor**
P1	Perception
P2	Set
P3	Guided Response
P4	Mechanism
P5	Complex Overt Response
P6	Adaptation
P7	Organization

C. List of Knowledge Profile

To attain all the POs [PO1 – PO12] the course curriculum of the undergraduate program encompasses all of the following attributes of the Knowledge Profile [K1 – K8].

Knowledge Profile	Attribute
K1	A systematic, theory-based understanding of the natural sciences applicable to the discipline
K2	Conceptually based mathematics, numerical analysis, statistics and the formal aspects of computer and information science to support analysis and modeling applicable to the discipline

K3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
K4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
K5	Knowledge that supports engineering design in a practice area
K6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
K7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the engineer's professional responsibility to public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability
K8	Engagement with selected knowledge in the research literature of the discipline

D. Range of Complex Engineering Problem Solving

Attribute	**Complex Engineering Problems** have characteristic P1 and some or all of P2 to P7:
Depth of knowledge required	P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8 which allows a fundamentals-based, first principles analytical approach
Range of conflicting requirements	P2: Involve wide-ranging or conflicting technical, engineering and other issues
Depth of analysis required	P3: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models
Familiarity of issues	P4: Involve infrequently encountered issues
Extent of applicable codes	P5: Are outside problems encompassed by standards and codes of practice for professional engineering
Extent of stakeholder involvement and conflicting requirements	P6: Involve diverse groups of stakeholders with widely varying needs
Interdependence	P7: Are high-level problems including many component parts or sub-problems

E. Range of Complex Engineering Activities

Attribute	**Complex activities** means (engineering) activities or projects that have some or all of the following characteristics:

Range of resources	A1: Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies)
Level of interaction	A2: Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues
Innovation	A3: Involve creative use of engineering principles and research-based knowledge in novel ways
Consequences for society and the environment	A4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
Familiarity	A5: Can extend beyond previous experiences by applying principles-based approaches

F. Format of the Course Outline (Theory)

14.i Title of the Course (Course Code)

14.i.1 Introduction of the Course

Course Code and Title:

Credits and Contact Hours: 3.0 Credits, 168 Contact Minutes per Week

Rationale of the Course:

Prerequisites (if any):

14.i.2 Course Objectives

The students are expected to

1)

2)

14.i.3 Course Content

As approved by the Academic Council of the University of Dhaka

14.i.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1				Lectures Discussions	Assignment Presentation
CO2				Exercise Handouts	Incourse Final Exam
CO3					

14.i.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5

14.i.6 Course Structure/ Lecture Plan

N.B. Each lecture comprises of 1.5 contact hours.

Weeks	Lectures	Topics	COs

14.i.7 Assessment Pattern/ Strategy

1) Class Attendance: Class attendance will be recorded in every class.

2) Assignment/Presentation:

3) Incourse: There will be a minimum 1 incourse exam; if 2 or more incourse exams are taken then their average will be considered in final evaluation.

4) Final exam: A comprehensive Final exam will be held at the end of the semester as per the institutional ordinance.

Distribution of marks:

Attendance	5%
Assignment/Presentation	5–10%
Mid-term (Incourse)	25–30%
Final Exam	60%
Total	100%

14.i.8 Text Books and Reference Books

1)

2)

G. Format of the Course Outline (Lab)

14.j Title of the Course (Course Code)

14.j.1 Introduction of the Course

Course Code and Title:

Credits and Contact Hours: 1.5 Credits, 3 Contact Hours per Week

Rationale of the Course:

Prerequisites (if any):

14.j.2 Course Objectives

The students are expected to

1)

2)

14.j.3 Course Content

Experiments in relevance with the (Related Theory Course Code and Course Title) course.

Projects related to (Related Theory Course Code and Course Title) course contents to achieve specific program outcomes.

14.j.4 Course Outcomes (COs)

CO No.	CO Statement	Corresponding POs	Domain and Taxonomy Levels	Delivery Methods and Activities	Assessment Tools
CO1				Lectures, Coding, Workshop	Assignment/ reports, Lab test, Viva, Project
CO2				Lectures, Simulation, Experiment	Lab reports, Hardware demonstration
CO3				Group discussion, Project	Project report, Presentation, Viva, Quiz

14.j.5 Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	P 1	P 2	P 3	P 4	P 5	P 6	P 7	A 1	A 2	A 3	A 4	A 5

14.j.6 Course Structure/ Lecture Plan

N.B. Each lab class comprises of 3.0 contact hours.

Weeks	Modes	Topics	COs

14.j.7 Assessment Pattern/ Strategy

Assessment will be based on...

Distribution of marks:

Class Attendance	10%

Lab Reports	20%
Lab test/Viva/Quiz	30–40%
Lab Performance	20–30%
Final Project	0–20%
Total	100%

14.j.8 Text Books and Reference Books

1)

2)