



**Department of Nuclear Engineering
University of Dhaka
Dhaka – 1000, Bangladesh**

Syllabus for:

Degree: Bachelor of Science (B.Sc.) in Nuclear Engineering

General Rules and Regulations

Initial Proposal for the Semester System

The framework of the semester system (initial observations, suggestions and recommendations made by the committee):

Program: B. Sc. (Bachelor of Science) in Nuclear Engineering:

- 1. Admission:** Students will be admitted to the department as per university rules.
- 2. Duration of the Program:** 4 years.
- 3. Total Semesters:** $4 \times 2 = 8$ (2 semesters a year of 22 weeks each).
- 4. Total Number of Credits in 8 semesters (4 years):** 161.0
- 5. Breakdown of each semester (of 22 weeks each):**
 - a. Classes: 14 active weeks (1 day of each week must be reserved for makeup classes. If necessary, weekends can be used for makeup classes and extra/additional classes may be taken within the semester schedule to finish the course).
 - b. Break/PL: 2 weeks. No separate break for in-course examinations.
 - c. Semester Final Examinations: 2 weeks.
 - d. Evaluation of Scripts and Publication of Results: 3 weeks (2 weeks for grade submission and 1 week for tabulation and result publication).
 - e. Vacations: No separate semester break. Only the usual university vacations apply.
- 6. Teaching of the courses:**
 - a. For each credit of a theory course, there will be 1 class per week of 1 hour duration.
 - b. Total classes in a semester for each credit of a theory course will be 14 (14×1).
 - c. Total Contact Hours in a semester for each 1.0 credit theory course: $14 \times 1 = 14$.
 - d. For each 1.5 credit lab course, there will be 1 class per week of 2.5 hours duration.
 - e. Total classes in a semester for each 1.5 credit lab course in 14 weeks: $14 \times 1 = 14$.
 - f. Total Contact Hours in a semester for each 1.5 credit lab course: $14 \times 2.5 = 35$.

7. Evaluation of the courses:

The answer scripts will be evaluated by two teachers within the department. In special case 2nd examiner may be selected from the other department of the faculty or from IIT.

8. Grading System: The current 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

9. Marks Distribution

a. For a theory course:

i. Attendance	05%
ii. Assignment/Presentation	05%
iii. Incourse	20%
iv. <u>Final Examination</u>	<u>70%</u>
Total Marks	100%

b. For 9a (iii), at least 2 Incourse examinations should be taken. One near the 5th/6th week and the other near the 11th/12th week.

c. The subsections (i)-(iii) of (9a) will ONLY be evaluated by the respective course teacher. Subsection (iv) will first be evaluated by the respective course teacher and, if necessary (case-7g), by the examination committee.

d. For a lab course:

i. Attendance	10%
ii. Continuous Assessment	50%
iii. Reports	20%
iv. <u>Viva</u>	<u>20%</u>
Total Marks	100%

In each lab course, some assignments will be provided which have to be solved by the students individually or in a group. The total number assignments given per lab course will be determined by the respective lab teachers. Each assignment has to be submitted during the lab time on the same day as the assigning date or some time later on a different day which will be determined by the respective lab teachers. For late submission, there will be some sort of penalty which will also be determined by the respective lab teachers. There can be bonus marking, if needed and felt necessary by the respective lab teachers.

10. Attendance

Students with 75% attendance and above in each course will be eligible to sit for the semester final examinations. Students having attendance $\geq 60\%$ and $< 75\%$ will be considered to sit for the examination after paying the some required fines. Students having attendance below 60% will not be eligible to appear at the examination. The marks distribution for attendance is given below:

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. Course Coordinator:

Each academic year will have a course coordinator. The coordinator will prepare class routine, monitor classes, arrange extra classes if necessary, ensure smooth functioning of the academic works, and help the Chairman (of the examination committee) in holding examinations and publishing results.

12. Class Representative:

Each batch/section of students will have two class representatives (one male and one female) to maintain liaison with the Course Coordinator regarding their class progress and problems.

13. Examination Committee:

- a. The examination committee consisting of 4 teachers will be proposed by the Academic Committee of the department.
- b. There will be an examination committee for every academic year.
- c. The committee will consist of a Chairman, 2 internal members and an external member. The Course Coordinator should be one of the members of the committee.
- d. The committee may have the external member from DU or outside DU.
- e. The Chairman of the examination committee, with the help of the committee members, will be responsible for getting questions from the respective course teachers, moderating the questions and printing them, holding examinations and publication of results.

14. Tabulators:

- a. The examination committee will appoint two tabulators.
- b. Course teachers/examiners will submit their grade-sheets in details.
- c. The tabulators will enter the marks given by each course teacher/examiner in the tabulation sheets independently and process the examination results.
- d. The controller's office will publish the examination results at the end of every semester and issue the transcripts.

15. Promotion from and the Final Degree:

- a. The minimum CGPA (Cumulative Grade Point Average) 2.00, 2.25, 2.5 will be required for promotion from 2nd, 4th, 6th semester to the next respectively (year to year promotion).

- b. $CGPA = \frac{\sum G_i \cdot C_i}{\sum C_i}$, where, G_i is the grade point obtained in course i and C_i is the corresponding credit.

- c. The minimum GP of 2.00 is required in each theory course and an overall CGPA of 2.5 will be required for award of the B. Sc. Degree.
- d. The Degree must be earned within the limit of 12 semesters, i.e. 6 academic years from the date of admission to the 1st semester.
- e. There will be no option for grace.

16. Re-admission and Drop Out:

- a. A student failing to get promotion may seek re-admission to study with the following batch. In the case of re-admission, all previously earned grades for the two semesters of that year will be cancelled.
- b. A student may take re-admission only 2 times. If required, a student may take re-admission in the same class, but the Degree must be completed within 6 years.
- c. A student failing to get minimum required CGPA even after taking re-admission twice will be dropped out of the program.

17. Improvement of Grades:

- a. A student will be allowed maximum of 2 chances to clear F grade/grades with the immediate next batches by complying with the time requirement for the degree including final year (4th year). A student will not be allowed for grade improvement once s/he is eligible for the degree. During the extra period for clearing F grades student will not be allowed remain in residential halls.
- b. A student getting F grade in any theory course (courses) has to attend only the final examination for that (those) course (courses).
- c. A student may improve grade/grades of any course only once by reappearing at the examination with the immediate next batch if he/she obtains a grade less than or equal to C+ (GP=2.50) and the best grade that a student can achieve in case of grade improve is B+.
- d. In addition to the usual fees, a fine, as per university rules, will be imposed for each course chosen for improvement.
- e. A student will have to be mentally prepared to take the examination of a particular course chosen for improvement even if it is held on the same day of his/her other regular examination.

Elaboration of Course Code:

N – Nuclear

E – Engineering

1st Digit – Represent year of the offered course

2nd Digit – Represent semester of the offered course

3rd and 4th Digit - Represent offered course number (Odd Number: Theory Course; Even Number: Lab Course.)

YEAR WISE COURSE DISTRIBUTION**FIRST YEAR FIRST SEMESTER:**

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 1101	Introduction to Nuclear Science and Engineering	3.0
NE – 1103	Physics – I (Mechanics, Oscillations, Waves and Elastic Properties of Matter)	3.0
NE – 1105	Fundamentals of Thermodynamics and Heat Transfers	3.0
NE – 1107	Computer Programming – I	3.0
NE – 1109	English Composition and Communication Skills	3.0
NE – 1102	Engineering Drawing Lab	3.0
NE – 1104	Workshop Practice Lab	1.5
Total		19.5

FIRST YEAR SECOND SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 1201	Physics – II (Electricity, Magnetism and Physical Optics)	3.0
NE – 1203	Fundamentals of Nuclear Physics	3.0
NE – 1205	Differential and Integral Calculus	3.0
NE – 1207	General and Radiochemistry	3.0
NE – 1209	Computer Programming – II	3.0
NE – 1211	Sociology and Engineering Ethics	3.0
NE – 1202	Physics Lab	1.5
NE – 1204	General and Radiochemistry Lab	1.5
Total		21.0

SECOND YEAR FIRST SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 2101	Fundamentals of Electrical Engineering	3.0
NE – 2103	Ordinary and Partial Differential Equations	3.0
NE – 2105	Applications to Thermal Engineering	3.0
NE – 2107	Elements in Fluid Mechanics and Machinery	3.0
NE – 2109	Reactor Theory and Analysis	3.0
NE – 2111	Principle of Accounting	3.0
NE – 2102	Fundamentals of Electrical Engineering Lab	1.5
NE – 2104	Applications to Thermal Engineering Lab	1.5
Total		21.00

SECOND YEAR SECOND SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 2201	Electronics – I (Analog Electronics)	3.0
NE – 2203	Radiation Sciences and Health Physics	3.0
NE – 2205	Vector Analysis and its Applications	3.0
NE – 2207	Statistics for Engineers	3.0
NE – 2209	Nuclear Fuel Cycle and Radioactive Waste Management	3.0
NE – 2211	Engineering Economics	3.0
NE – 2202	Electronics – I (Analog Electronics) Lab	1.5
NE – 2204	Radiation Sciences and Health Physics Lab	1.5
Total		21.0

THIRD YEAR FIRST SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 3101	Electronics – II (Digital & Microprocessor)	3.0
NE – 3103	Materials Science for Nuclear Applications	3.0
NE – 3105	Thermal Hydraulics and Reactor Safety	3.0
NE – 3107	Complex Variables, Laplace Transformations, and Fourier Transformations	3.0
NE – 3109	Numerical Methods in Reactor Engineering Analysis	3.0
NE – 3111	Engineering Mechanics	3.0
NE – 3113	Foreign Language (Russian/French/German)	2.0
NE – 3102	Electronics-II (Digital + Microprocessor) Lab	1.5
NE – 3104	Thermal Hydraulics and Reactor Safety Lab	1.5
Total		23.0

THIRD YEAR SECOND SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 3201	Nuclear Electronics, Instrumentation and Measurement	3.0
NE – 3203	Electrical Power Transmission and Distributions	3.0
NE – 3205	Management in Engineering	3.0
NE – 3207	Automation and Control Engineering	3.0
NE – 3209	Biomedical Applications of Nuclear Technology	3.0
NE – 3202	Nuclear Electronics, Instrumentation and Measurement Lab	1.5
NE – 3204	Virtual Instrumentation Modeling and Simulation/MATLAB and LabVIEW	1.5
NE – 3206	Nuclear Power System Design Project	1.5
NE – 3208	Industrial Training	1.5
Total		21.0

FOURTH YEAR FIRST SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 4101	Environment and Nuclear Disaster Management	3.0
NE – 4103	Nuclear Power Plant Design and Features	3.0
NE – 4105	Research Methodology, Scientific and Technical Writing	2.0
NE – 4107	Fusion Power Engineering	3.0
NE – 4109	Introduction to Nanoscience and Nanotechnology	3.0
NE – 4111	NEOP – 1	3.0
NE – 4000	Research Thesis/Project	2.0
Total		19.0

FOURTH YEAR SECOND SEMESTER:

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NE – 4201	Advanced Nuclear Reactors Design and Features	3.0
NE – 4203	Nuclear Safety, Security and Safeguards Issues	3.0
NE – 4205	Radiation Transport Safety and Shielding	3.0
NE – 4207	NEOP – 2	3.0
NE – 4000	Research Thesis/Project	2.0
NE – 4202	Reactor Operation and Experiments Lab	1.5
Total		15.5

Optional Courses (NEOP)

<i>Course Code</i>	<i>Course Title</i>	<i>Credit Hour</i>
NEOP	Modern Physics and Introduction to Quantum Mechanics	3.0
NEOP	Beams and Accelerators	3.0
NEOP	Radiation Imaging	3.0
NEOP	High Intensity Laser Plasma Interaction	3.0
NEOP	Decommissioning Management and Procedure	3.0
NEOP	Nuclear Chemical Engineering	3.0

TOTAL CREDIT OF B.Sc. IN NE:

Year and Semester	Credit Total
First Year First semester	19.5
First Year Second semester	21.0
Second Year First semester	21.0
Second Year Second semester	21.0
Third Year First semester	23.0
Third Year Second semester	21.0
Fourth Year First semester	19.0
Fourth Year Second semester	15.5
Grand Total	161.0

DETAILED SYLLABUS FOR B.Sc. IN NUCLEAR ENGINEERING

FIRST YEAR FIRST SEMESTER:

Course Title: Introduction to Nuclear Science and Engineering

Course Code: NE–1101

Credit Hour: 3.0

Course Description

This course is designed to help the students to get a basic idea of nuclear science and engineering. The course mainly focuses on the basics of nucleus, radioactive decay, energy released in nuclear reactions, chain reaction, and comparison of nuclear energy with other sources, world nuclear power development, and nuclear power in Bangladesh. It also covers the basics of radiation and application of radioisotopes. This course will set up a strong basis for several courses of the next semesters.

Learning outcomes

After completing this course the students are expected to be able to

- Describe the constituents of nuclei and atoms, nuclear binding energy, how binding energy is related to energy released in reaction, basics of radioactive decay, variation of reaction cross section with energy.
- Calculate the mass defect, binding energy of nucleus, decay rate, energy released in different reaction e.g. chemical reaction, nuclear fission and fusion reaction, radioactive decay etc.
- Understand the different steps in neutron life cycle, how multiplication factor is related to reactivity and operating state of nuclear reactor
- Comprehend the present scenario of different energy sources in Bangladesh as well as in the world and the need of nuclear energy.
- Illustrate the chronological development of nuclear power, how the electricity is generated from nuclear reactor, reactor classification, basic characteristics of research and power reactors.
- Be familiar with the national nuclear energy program, research, education and career developments in nuclear science and engineering.
- Explain the sources and types of radiation, production and uses of radioisotopes in nuclear medicine and industry.

Course syllabus

Topic	Contents
Nuclear Reactions	Equivalence of mass and energy, conservation of mass energy, atom, nucleus, atomic number, atomic mass number, isotopes, binding energy, radioactivity, stable and unstable nuclei, types of binary nuclear reaction, concept of cross section, classification of neutron, energy in chemical reactions, energy in nuclear fission reactions, energy in fusion reactions, nuclear chain reaction, neutron multiplication factor, six factor formula, concept of reactivity, subcritical, critical and super critical state of nuclear reactor.
The Motivation of Nuclear Energy	The need, availability and potentiality of energy sources for global and Bangladesh perspectives; problems with fossil fuels; energy and environment concerns, availability of nuclear fuels, new energy development technologies, nuclear power as a substitute for fossil fuels, the potential role of nuclear energy for energy future security.
Nuclear Power Development	Early history of reactor development, component of nuclear reactor and nuclear power plant (NPP), classification of nuclear reactor, characteristics and applications of research reactor, power reactor characteristics, different types of power reactor, working principle of NPP, worldwide development of nuclear powers, present trend, national program of nuclear energy development, nuclear research, education and career developments.
Radiation and Radioisotope	Definition of radiation, types and sources of radiation, concept of radiation dose and radiation protections. Different types of radioisotopes, their production and applications in medical sciences and industry.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 4 th (8)	Nuclear Reactions
	5 th – 7 th (6)	The Motivation of Nuclear Energy
	8 th - 12 th (10)	Nuclear Power Development
	13 th - 14 th (4)	Radiation and Radioisotope
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Fundamentals of Nuclear Science and Engineering, J. Kenneth Shultis, Richard E. Faw, Kansas State University Manhattan, Kansas, U.S.A. ISBN: 0-8247-0834-2, 2002.
- Introduction to Nuclear Engineering, John R. Lamarsh, Anthony J. Baratta, Third Edition, ISBN 0-201-82498-1.
- Raymond L. Murray, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Process, Sixth Edition, Elsevier Inc. 2009. ISBN: 978-0-12-370547-1.
- David Bodansky, Nuclear Energy: Principles, Practices, and Prospects, Second Edition, Springer-Verlag New York, LLC, 2004. ISBN: 0-387-20778-3.

Course Title: Engineering Drawing

Course Code: NE- 1102

Credit Hour: 1.5

Course Description:

Introduction to Mechanical Drawing, Introduction to Lettering, Numbering and Heading, Instrument and their Uses, First and Third Angle Projections, Orthographic Drawings, Missing Lines and Views, Sectional Views and Conventional Practices, Auxiliary Views, Pictorial Drawing- Isometric Views, Surface Development, Introduction to Computer Aided Drawing.

Learning Outcomes:

This course is a lab course based on the title covered with Engineering Drawing. The students will familiar with different aspects related to engineering drawings. The specific objectives of

this course are to build clear concept about fundamentals and details of Engineering Drawings (2 D and 3D) through manual drawings and CAD practices.

- The students should be proficient in using engineering drawing apparatus, materials and techniques
- Students should be able to use and interpret standard conventions used in engineering drawing

Course Syllabus

Topic	Contents
Manual Drawings	
Introduction to Engineering Drawing	The students will learn different aspects related of Engineering Drawing such as lettering, numbering and heading, dimensioning, use of instrumentation for drawing, etc.
First and Third Angle Projections	The students will be able to know about first and third angle projections and how to draw them.
Orthographic Drawings	The students will learn how to draw 3D object based on 2D orthographic views.
Sectional and Auxiliary Views	The students will learn how to draw sectional views and auxiliary views. They also learn the conventions related these kinds of views.
Isometric Views	The students will learn how to draw 3D isometric views from 2D orthographic views.
Surface Development	
Computer Aided Design (CAD) drawing	
Introduction to CAD	The students will come to know the basic techniques of CAD drawing using CAD software, e.g. SOLIDWORKS.
CAD drawing practices	The students will do the similar tasks of manual drawings using CAD software (Solidworks). In addition, they will also learn how to draw complex drawings (2D and 3D) using CAD software. SOLIDWOKS.

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Introduction to Engineering Drawing
	2 nd (2)	First and Third Angle Projections
	3 rd (2)	Orthographic Drawings
	4 th (2)	Sectional and Auxiliary Views
	5 th – 6 th (4)	Isometric Views
	7 th -8 th (4)	Introduction to CAD
	9 th -14 th (10)	CAD drawing practices

Recommended Readings

1. Dhananjay A Jolhe, Engineering drawing, Tata McGraw-Hill Education, 2008. ISBN: 9781259082894.
2. T E French, C J Vierck and R J Foster, Graphic Science and Design, 4th edition, McGraw Hill, 1984.
3. W J Luzadder and J M Duff, Fundamentals of Engineering Drawing, 11th edition, Prentice-Hall of India, 1995.
4. K Venugopal, Engineering Drawing and Graphics, 3rd edition, New Age International, 1998.
5. Manner, Introduction to Engineering Graphics Reader, 1st edition, no year given.
6. Bertoline and Weibe, Fundamentals of Graphics Communication, 6th edition, McGraw Hill Publishing, ISBN: 978-0-07-352263-0.

Course Title: Physics – I (Mechanics, Oscillations, Waves and Elastic Properties of Matter)

Course Code: NE-1103

Credit Hour: 3.0

Course Description

This course is designed to enable the students to achieve an in-general conceptual knowledge of mechanical physics. The course mainly focuses on the different aspects of motion, Newtonian physics. Analysis of kinetics will help students to understand basic mechanism of different physical aspects. The students are expected to have the conceptual basics of intermediate physics.

Learning Outcomes

After completing this course, the students should be able to:

- Understand the objective, definition and different aspects of mechanics.
- Explain the basic physical terms.
- Describe the Newton's Law and its application.
- Illustrate the knowledge of work and kinetic energy.
- Understand the momentum and collisions.
- Be familiar with the elements of waves.
- Gain an idea on physics in nuclear engineering.

Course Syllabus

Topic	Contents
Introduction to Physics	The nature of Physics, Standards and units, unit conversions, Overview of vectors
Kinematics	Speed and velocity, Constant velocity motion, Acceleration, constant acceleration problems, acceleration of gravity, Projectile motion, Circular motion (uniform and non-uniform), Relative velocity
Newton's Laws of motion	Force and interactions, Newton's first, second and third laws, Free body diagram, Application of first law: particles in equilibrium, Application of second law: Dynamics of particles, Working principle of satellites, Frictional forces, Dynamics of circular motion, Fundamental forces of nature
Work and energy	Work by constant and varying forces, Kinetic energy- work energy theorem, Power, Gravitational potential energy, Elastic potential energy, Conservative and non-conservative forces, Force and potential energy, Energy diagram

Topic	Contents
Momentum	Momentum and impulse, conservation of momentum, Collisions: elastic and non-elastic, Center of mass, Energy of a system of particles, 2D-elastic collisions, Ballistic pendulum
Rotation of rigid bodies	Angular velocity, acceleration and momentum, Relation between angular and linear kinematics, Parallel axis theorem, Moment of inertia, Torque\Rigid body rotation about a moving axis
Oscillations	Periodic phenomena (oscillations and waves), spring-mass system, simple harmonic motion, energy in SHM, simple pendulum, physical pendulum, torsional pendulum, small angle approximation, simple harmonic oscillation, Periodic phenomena (oscillations and waves), Spring-mass system, Simple harmonic motion, energy in SHM, Simple pendulum, physical pendulum, torsional pendulum, Damped oscillation, forced oscillation and resonance

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In course Examination	15
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1st (2)	Introduction
	2nd -3th (4)	Kinematics
	4th-6th (6)	Newton's Laws of motion
	7th-8th (4)	Work and energy
	9th-10th (4)	Momentum
	11th-12th (4)	Rotation of rigid bodies
	13th -14th (2)	Oscillations
	5th Week	1st in course examination
	11th Week	2nd in course examination

Recommended Readings

- Young, Hugh, Lewis Ford and Roger Freedman. *University Physics*. Reading, MA: Addison-Wesley, 2003. ISBN: 0321500628.
- David Halliday, Robert Resnick and Jearl Walker. *Principle of Physics*. Extended, 9th ed. Wiley, 2010, ISBN : 978-0-470-56158-4.
- Serway, Raymond A., and John W. Jewett. *Physics for Scientists and Engineers (with PhysicsNOW and InfoTrac)*. Belmont, CA: Thomson-Brooks/Cole, 2003. ISBN: 9780534408428.
- Ohanian, Hans C. *Physics*. Vol. 1. 2nd ed., expanded. New York, NY: Norton, 1989. ISBN: 9780393957501.
- Ohanian, Hans C., and John T. Markert. *Physics for Engineers and Scientists*. Vol. 1. 3rd ed. New York, NY: Norton, 2007. ISBN: 9780393930030.
- French, A. P. *Vibrations and Waves*. New York, N.Y.: W.W. Norton & Company, January 1, 1971. ISBN: 9780393099362.
- Tipler, Paul A., and Gene Mosca. *Physics for Scientists and Engineers: Extended Version*. New York: W.H. Freeman, 2003. ISBN: 9780716743897.
- Giancoli, Douglas C. *Physics for Scientists and Engineers with Modern Physics*. Upper Saddle River, NJ: Pearson Education, 2007. ISBN: 9780130215192.
- Resnick, Robert, David Halliday, and Kenneth S. Krane. *Physics*. New York, NY: Wiley, 2001. ISBN: 9780471401940

Course Title: Workshop Practice Lab

Course code: NE-1104

Credit Hour: 1.5

Course Description

Foundry: Introduction to foundry, tools and equipment; Patterns: function, pattern making; Molding: molding materials sand preparation, types of mold, procedure; Cores: types, core making materials; Metal melting and casting; Inspection of casting and casting defects.

Introduction about different types of tools; hand tools, power tools, Safety rules for workshop practices

Practices on machine tools: lathe machine, drilling machine, shaper machine, milling machine, grinding machine.

Metal joints: riveting, grooving, soldering,

Welding practice: Electric arc welding, spot welding, pressure Welding, TIG, MIG

Learning Outcomes

After learning the course the students should be able to;

- Explain and strictly adhere to the rules and safety regulations for work in the mechanical workshop

- Understand applications of hand tools and power tools.
- Understand the operations of machine tools.
- Properly operate the manufacturing equipment in the mechanical workshop
- Create and document a typical process plan for manufacturing of a product in the mechanical workshop
- To perform the welding techniques and understand important of different types of welding for manufacturing a product
- Select proper tools and cutting data for a given material and manufacturing process

Course Components (Learning Activities)

Class, Assignment, Prattice, Report, and Viva-voce

Assessment Type

Activities	Percentage (%)
Continuous assessment for attendance, assignment, report, job practices	50
Final Practical	20
Final Report	10
Viva-Voce	20

Course Schedule

One class 3-hour duration per week. Total number of classes will be 14 weeks in one semester.

Recommended Readings

Machine Shop Practice – James Anderson, W. A. Chapman.

Course Title: Fundamentals of Thermodynamics and Heat Transfer

Course Code:NE-1105

Credit Hour: 3.0

Course Description

In this course, the basic laws of thermodynamics and the governing equations for heat transfer and thermodynamics will be introduced and subsequently used to solve practical engineering problems involving thermodynamics and heat transfer. This course will give an understanding to develop a fundamental understanding of the processes by which heat and energy are inter-related and converted and by which heat is transferred. The unit will review major principles of energy conversion and the modes of heat transfer (conduction,

convection, and radiation heat transfer). The unit will also cover fundamental design principles of power generation systems and heat exchangers.

Learning Outcomes

After completing this course the students should be able to

- Define the thermodynamics properties; temperature, pressure, entropy etc;
- Describe the type of thermodynamic systems, isolated, open and closed systems;
- Describe the thermodynamic processes, cyclic, reversible, non-reversible, adiabatic, isentropic, throttling, polytrophic processes etc. ;
- Distinguish between extensive and intensive properties;
- State and apply the first and second law of thermodynamics;
- Able to perform energy balances on all major components in the system such as heat exchangers;
- Apply the ideal gas laws to solve for the unknown pressure, temperature, or volume;
- Calculate the work done in constant pressure and constant volume processes; and
- Apply fundamental equations to establish mathematical relationships amongst commonly encountered thermodynamic properties.
- Identify modes of heat transfer in energy-related processes.
- Appraise engineering problems involving heat conduction, convection and radiation by selecting and applying appropriate tools to model the problem

Course Syllabus

Topic	Contents
Fundamental concepts	Thermodynamics and Energy, Closed and open system, macroscopic and Microscopic Energy, Properties of system, State and equilibrium, Process and cycles, Pressure and Temperature
Energy and First law of Thermodynamics	Work and Kinetic energy, Potential energy, Conservation of energy, power, Quasi equilibrium expansion or compression processes, Energy Transfer and energy balance Energy analysis of cycles

Topic	Contents
Control volume analysis	Conservation of mass for a control volume, Conservation of energy for a control volume, steady state analysis, Applications to nozzles, diffusers, Turbines, compressors, pumps, Heat Exchangers, throttling devices
Second law of thermodynamics	Statements, reversibility and irreversibility, Applying second law to Refrigeration, Heat Pump and Carnot cycle
Entropy Analysis	Entropy change, Tds equations, Entropy change for ideal gas and internally reversible process, Entropy balance and entropy rate balance for a closed system
Thermodynamic cycles	Otto cycle, Diesel cycle, Brayton cycle and Rankin cycle
Conduction heat transfer	Fourier's law, thermal conductivity and thermal resistance, General heat conduction equation in Cartesian, cylindrical and spherical coordinates, Heat conduction through plane and composite walls, overall heat transfer coefficient, Heat conduction through plane and composite cylinder and sphere, Heat conduction with internal heat generation
Convection heat transfer	Free convection and forced convection, internal and external flow, simple empirical relations
Radiation heat transfer	Thermal radiation, Black body radiation, Emissivity, Radiation configuration factor

Course Components (Learning activities)

Lecture, Discussion, Assignment, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5

Activities	Percentage (%)
In-course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 th (4)	Fundamental concepts
	3 th (2)	Energy and First law of Thermodynamics
	4 th – 5 th (4)	Control volume analysis
	6 th (2)	Second law of thermodynamics
	7 th – 8 th (4)	Entropy Analysis
	9 th (2)	Thermodynamic cycles
	10 th -12 th (6)	Conduction heat transfer
	13 th (2)	Convection heat transfer
	14 th (2)	Radiation heat transfer
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Michael J. Moran., Howard N. Shapiro, “Fundamentals of Engineering Thermodynamics”. John Wiley and sons, Inc. (5th edition)
- Er. R. K. Rajput, “Heat and mass transfer”. S. Chand and company limited. (5th Edition)
- DOE fundaments handbook. “Thermodynamics, heat transfer and fluid flow”. Volume 2 of 3.
- Tester, Jefferson W., and Michael Modell. *Thermodynamics and its Applications*. Upper Saddle River, NJ: Prentice Hall, 1996. ISBN: 9780139153563.
- YunusA.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
- Holman.J.P, Heat Transfer, Tata McGraw Hill, 2002.
- Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
- Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.

- Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
- Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
- Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995

Course Title: Computer Programming-I

Course Code: NE-1107

Credit Hour: 3.0

Course Description:

The purpose of the course is to provide the fundamentals of programming. It is an introduction to computer concepts, logic, and computer programming. It includes designing, coding, debugging, testing, and documenting programs using a high-level programming language.

Learning Outcomes

Upon successful completion of this course, students will:

- Understanding foundation concepts of information and information processing in computer systems: a matter of information, data representation, coding systems.
- Understanding of an algorithm and its definition.
- Understanding of programming language syntax and its definition by example of C language.
- Knowledge of basic principles of imperative and structural programming.
- Ability to write simple programs in C language by using basic control structures (conditional statements, loops, nested loops, switches, branching, etc.).
- Ability to create a programmable model for a problem given.
- Understanding a function concept and how to deal with function arguments and parameters.
- Ability to use pointers and pointer arithmetic in the simple cases. Basic knowledge of working with arrays in C language.
- Understanding a defensive programming concept. Ability to handle possible errors during program execution.
- Elementary knowledge of programming code style.

Course Syllabus

Topic	Contents
Review of Basics	Basic I/O, Data Type, Conditional Logic, Switch Case, Character, ASCII Value, Reading and Writing Character, Integer to Character Conversion
Operators	Arithmetic, Relational, Logical and Bitwise Operators, Operator Precedence and Associativity, Arithmetic Expression Evaluation, Short Cut Operator.
Functions- I	Basic Functions, Void Functions with No Parameters
Loops	Looping Basic, Necessity of Loops, While Loop, Loop Condition, Body, Initialization, Increment, For Loops, Part of For Loops, Do While Loop,

Topic	Contents
	Entry Controlled Loops, Exit Controlled Loops, Example, Formulating Problems Using Loops.
Formatted I/O	Specifying Width using Format Specifier in printf and scanf in Details.
Nested Loop	Nesting of Two Loops, Example, Nesting of Independent Loops inside One, Example, Nesting of More Than Two Loops.
Functions - II	Functions with Return Type and Trivial Parameters, Local and Global Variables, Call by Value, Library Functions/Header Files Concept.
Arrays	Basics of Array, Necessity, Declaration, Accessing through Indices, Accessing using Loops, Initialization, Example, Two Dimensional Arrays, Declaration, Initialization, Accessing through Loops, Example, Multidimensional Arrays, Example.
Functions - III	Passing Arrays in a Function as Parameter, Call by Reference, Recursion, Scope Visibility and Lifetime of Variable.
Strings	Basics, Difference between String and Character Array, I/O, Basic Operations without using Library Functions, Array of Strings
String Library	Basic String Operations, Length, Compare, Concatenate, Substring, Reverse.
Structures	Basics, Necessity, Declaration, Accessing, Initialization, Array of structures.
Pointers	Basics, Uses, Pointer Operation, Call by Reference using Pointers, Pointer for 1D/2D/3D Array, Structure, Pointer Expression, Array of Pointers, Function Returning Pointers.
Dynamic Memory Allocation	Basics, Uses, Malloc, Free, Calloc, Realloc.
File Operation	Basics, Uses, File Opening, Closing, File I/O

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In course Examination	15
Semester Final Examination	70

Class Schedule

One class 3-hour duration per week. Total number of classes will be 14 weeks in one semester.

Recommended Readings:

1. Kernighan, Brian, and Dennis Ritchie. The C Programming Language. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1988. ISBN: 9780131103627.
2. [Schildt](#). Teach Yourself C++, Tata McGraw-Hill Education, 1998. ISBN: 9780074638705.
3. Perry, Greg, CProgramming Absolute Beginner , 3rd Edition, Que Publishing; 3 edition (August 17, 2013), ISBN-10: 0789751984.
4. Problem_Solving_and_Program_Design_in_C - Jeri R. Hanly, Elliot B. Koffman, Pearson; 8 edition (February 27, 2015) 8th Edition, ISBN-10: 0134014898.
5. Programming in Ansi C- Balaguruswamy, Third Edition, McGraw-Hill; 7th edition (December 9, 2017), ISBN-10: 9789339219666.

Course Title: English Composition and Communication Skills

Course Code: NE 1109

Credit: 3.0

Course Description

The course is designed for the students of Nuclear Engineering Department to improve their English skills in all areas and also increase their confidence using English in everyday situations. The course aims to focus on the four major skills of reading, writing, speaking and listening so that the students learn how to use the correct pronunciation of vocabulary, have discussions about news and current affairs, and know more about culture and customs. Moreover, they should also learn how to learn (Strategies for learning English).

Learning Outcomes

After completing the course, the students should be able to communicate with a greater understanding of the English language structure, including: grammar points, English sounds and intonation patterns, reading skills, writing fluency and conversation skills.

- To comprehend descriptions of topics from a variety of texts
- To apply different reading skills: Skimming, Scanning, Inferring, Predicting etc.
- To develop vocabulary connected with topics such as leisure, work and employment, entertainment, travel, home, money etc.
- To describe impressions, feelings, experiences in writing
- Academic/ formal and informal writing
- To apply different writing skills: structure, pre-writing activities, cohesion & coherence, editing
- To be able to listen for specific and general purposes
- To focus on the key words
- To be able to understand speech on a variety of subjects such as work, lecture, leisure or the current affairs.
- To be able to talk about familiar topics and to give explanations and reasons for suggestions, opinions, past actions and future plans

- To recount the story of a book or film and deal with most situations in an English speaking environment.
- To review and apply the body of rules surrounding English grammar in everyday contexts

Course Syllabus

Topic	Contents
Reading	Literary and non-literary texts, Newspaper articles, Advertisements, Reports
Writing	Process of writing, Paragraph & Essay (Descriptive, Narrative, Cause & Effect, Compare & Contrast, Argumentative), Formal Applications & CV
Listening & Speaking	Conversations, Role plays, Interviews, Movie clips, Songs, Storytelling, Short presentations, Advertising
Grammar	Subject-verb Agreement, Prepositions, Tenses, Sentence structure, Run-on, Fragments

Course Components

Lecture, film/ book review, Discussion, Assignment, Interactive Tutorial

Assessment Type:

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st -3 rd (6)	Reading
	4 th – 6 th (6)	Writing
	7 th -12 th (12)	Listening & Speaking
	13 th -14 th (4)	Grammar

Recommended Readings

1. Endeavour: An Introductory Language Coursebook, Department of English University of Dhaka
2. Langan, J., College Writing Skills with Readings Murphy
3. Raymond, Essential English Grammar
4. Writing for the Technical Professions, 3rd Edition, Kristin Woolever, Pearson Education, Inc., 2005.
5. The Elements of Style, 4th Edition, William Strunk Jr. and E.B. White, Allyn& Bacon, 2000.
6. English Composition and Grammar, John E. Warriner, Harcourt Brace Jovanovich, 1988. ISBN: 9780153117336.
7. Practical English Composition, Edwin L. Miller, Illustrated Edition, General Books LLC, 2010. ISBN: 9781153761109.

FIRST YEAR SECOND SEMESTER:

Course Title: Physics-II (Electricity, Magnetism and Physical Optics)

Course Code: NE-1201

Credit Hour: 3.0

Course Description

This course is designed to facilitate the students to acquire a thorough idea of Electricity, Magnetism. The course mostly focuses on Electric fields determination of discrete and continuous charge distribution, Motion of charge particles in magnetic field, Electromagnetic Induction and Inductance and Oscillating circuit. The course also covers Electromagnetic waves, Physical Optics. The students should have a basic knowledge about high school physics, Basic mathematics, and calculus in order to complete this course effectively.

Learning Outcomes

After completing this course the students should be able to

- Understand the discrete and continuous charge distribution, electric field line and flux.
- Explain Gauss's and its applications, Faraday case, equipotential surface, potential gradient.
- Differentiate between electric potential energy and electric potential, Electric field and magnetic field line, Resistance and Resistivity.
- Get idea about Motion of charge particles in magnetic field, Force and torque on a current loop.
- Illustrate the Biot-Savart law, Ampere's law, Faraday's law, Lenz's law and their applications.
- Depict the Oscillating circuit.
- Be familiar with Maxwell's equations and electromagnetic waves generation.

- Calculate the Electric field, Electric potential , Potential energy, Capacitance, Current, resistance, Magnetic field, Magnetic force, Electromotive force,

Course Syllabus

Topic	Contents
Electric field	Introduction to electric field, math review related to electric field, Electric fields and discrete charge distributions, Electric fields and continuous charge distributions, Electric field line and Electric dipole.
Gauss's law	Charge and Electric flux, Calculating Electric flux, Gauss's Law, Application of Gauss's Law, Charges on conductors.
Electric Potential	Electric potential energy, Electric potential, Calculating electric potential, Equipotential surfaces, Potential Gradient.
Capacitors	Conductors and insulators, conductors as shields, Capacitors and Capacitance, Capacitors in series and parallel, Energy storage in capacitors and electric field energy, Capacitors and dielectrics, Gauss's law in Dielectric.
Circuits	Current, Current density, Resistance and Ohm's law, Resistivity, Batteries and circuit elements, Electromotive force and circuits, energy and force in Electric Circuit, DC circuits, DC circuits with capacitors.
Magnetic fields and force	Magnetic field, Magnetic field lines and magnetic flux, Motion of charge particles in magnetic field, Applications of motion of charged particles, Magnetic force on a current carrying conductor, Force and torque on a current loop.
Sources of Magnetic field	Magnetic field of a moving charge, Magnetic field of a current element, Magnetic field of straight current carrying conductors, Biot-Savart law, Ampere's law and their applications.
Electromagnetic Induction and Inductance	Faraday's law, Lenz's law, Motion of electromotive force, Induced electric field, Eddy currents, Displacement current and Maxwell's equation, pointing vector, Mutual and self-inductance, Magnetic field energy, RL circuit.
Oscillating circuit	Undriven RLC circuits, driven RLC circuits.
Electromagnetic waves	Maxwell's equations and electromagnetic waves generation, Plane electromagnetic waves and speed of light, sinusoidal electromagnetic waves, Energy and momentum in electromagnetic waves, dipole radiation.
Physical Optics	Theories of light, Hyugen's principle and construction, interference of light, Young's double slit experiment, Fresnel bi-prism, Newton's rings, interferometers, diffraction of light, Fresnel and Fraunhofer diffraction by single and double slit diffraction gratings, polarization, production and analysis of polarized light, optical activity, optics of crystals.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (4)	Electric field and Gauss's law
	3 rd (2)	Electric Potential
	4 th (2)	Capacitors
	5 th -6 th (4)	Circuits
	7 th (2)	Magnetic fields and force
	8 th (4)	Sources of Magnetic field
	9 th -10 th (4)	Electromagnetic Induction and Inductance
	11 th (2)	Oscillating circuit
	12 th (2)	Electromagnetic waves
	13 th -14 th (4)	Physical Optics
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Young, Hugh D., and Roger A. Freedman. *University Physics with modern Physics*. San Francisco, CA: Addison-Wesley, 2003. ISBN: 9780805386844.
- David Halliday, Robert Resnick and Jearl Walker. *Principle of Physics*. Extended, 9th ed. Wiley, 2010, ISBN: 978-0-470-56158-4.
- Serway, Raymond A., and John W. Jewett. *Physics for Scientists and Engineers (with PhysicsNOW and InfoTrac)*. Belmont, CA: Thomson-Brooks/Cole, 2003. ISBN: 9780534408428.
- Ohanian, Hans C. *Physics*. Vol. 1. 2nd ed., expanded. New York, NY: Norton, 1989. ISBN: 9780393957501.
- Ohanian, Hans C., and John T. Markert. *Physics for Engineers and Scientists*. Vol. 1. 3rd ed. New York, NY: Norton, 2007. ISBN: 9780393930030.
- Physics, David Halliday, Robert Resnic, Part-II ISBN 0 85226 355 4, Secon edition.
- Physics, David Halliday, Robert Resnic, Kenneth S. Krane, Volume-II, 5th edition.

Course Title: Physics Lab

Course Code: NE-1202

Credit: 1.5

Course Description

The objective of this course is to help the students to get a practical experience in the field of physics (Mechanics, Electricity, Light, Modern physics), to measure unknown quantities and draw conclusion from them, to write scientific reports and papers. The course mainly includes the study of basic physics laboratory instruments, determination of spring constant, the value of “g”, Young modulus, rigidity modulus, moment of inertia, Planck’s constant, specific charge of an electron, liquid viscosity and verification of inverse square law, $F = ma$ and also make a comparison of e.m.f of two cells with a potentiometer.

Learning Outcome

- Apply the various procedures and techniques for the experiments.
- Use the different measuring devices and meters to record the data with precision.
- Apply the mathematical concepts/equations to obtain quantitative results.
- Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

List of Experiments:

Expt. No.	Experiment Name
1	To measure the volume of a rod using Vernier calipers & Screw gauge.
2	To measure the radius of curvature of a spherical surface with a spherometer.
3	To determine the spring constant and effective mass of a given spiral spring and hence to calculate the rigidity modulus of the material of the spring.
4	To determine the value of g, acceleration due to gravity, by means of a compound pendulum.
5	To determine the Young’s modulus (Y), & rigidity modulus (n) of a short wire by Searle’s dynamic method.
6	To determine the moment of inertia of a fly-wheel about its axis of rotation.
7	To measure the value of Planck’s constant “h” using Light Emitting Diode (LED).
8	To measure the specific charge, i.e. charge to mass ratio ($\frac{e}{m}$) of an electron.
9	Verification of Inverse square law.
10	Verification of $F = ma$ by car dynamic system (Pasco method)
11	To compare the e.m.f of two cells with a potentiometer.
12	Determination of liquid viscosity

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week(Classess)	Experiment
1	1 st - 12 th	1-12
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Young, Hugh D., and Roger A. Freedman. University Physics with modern Physics. San Francisco, CA: Addison-Wesley, 2003. ISBN: 9780805386844.
- David Halliday, Robert Resnick and Jearl Walker. Principle of Physics. Extended, 9th ed. Wiley, 2010, ISBN: 978-0-470-56158-4.
- Practical Physics by Dr. Giasuddin Ahmed and Md. Shahabuddin Ahmed

Course Title: Fundamentals of Nuclear Physics

Course Code: NE-1203

Credit Hour: 3.0

Course Description

The “Fundamentals of Nuclear Physics” course is designed to help the students for basic understanding of nuclear physics. The course mostly deals with the structure of nucleus, nuclear models, nuclear stability and radioactive decay. Special attentions are given in nuclear reactions. The course also covers the topic “interaction of radiation with matter” in details. The students should have a basic idea of quantum mechanics in order to comprehend some of the topics. This course will provide a foundation for understanding some of the courses in the following semesters especially for Reactor Theory and Analysis as well as Radiation Science and Health Physics.

Learning Outcomes

After completing this course the students are expected to be able to

- Comprehend the mutual interactions among fundamental particles, constituents of nucleus, nuclear force and binding energy.
- Understand the liquid drop model and hence semi-empirical mass formula and its applications.
- Explain the nuclear size and various methods of nuclear size determination in details.
- Describe the different types of radioactive decay, their energetic, decay series, radioactive equilibrium, techniques of activity measurement, application of radioactivity.
- Illustrate the interaction modes of different types of radiation e.g. neutron, alpha, beta and gamma and different parameters of radiation interactions.
- Depict the various types of nuclear reactions, their Q-values, reaction cross section and basics of chain reaction.
- Be familiar with different nuclear models namely shell model, collective model and optical model.
- Calculate the nuclear radius, binding energy, decay rates, half-life, life time of geological and archeological samples, radioisotope production rate, different attenuation coefficient, reaction cross section, nuclear reaction Q-value, and energy released in fission and fusion reaction etc. The students will also be able to calculate the nuclear magnetic moment and angular momentum.

Course Syllabus

Topic	Contents
Introduction to nuclear physics	Rutherford atom and atomic nucleus; atomic density, Nuclear size; Packing fraction and binding energy and semi-empirical mass formula; separation energy, Nuclear force Nuclear nomenclature, binding energy and semi-empirical mass formula.
Radioactive decay	Radioactivity calculations, nuclear stability and radioactive decay, Radioactive decay laws, excited states and radiation, Carbon dating; Half-life and mean life; Secular and transient equilibrium; Radioactive series; alpha decay, Gamma decay, beta decay.
Interaction of radiation with matter	Ionization, beam description, beam attenuation, attenuation coefficient, and energy transfer coefficient, energy absorption coefficient. Neutron Interactions, neutron attenuation, Gamma ray interaction, Energy loss in the scattering collision,
Nuclear structure	Characteristics of the nuclear force, the deuteron, nuclear models
Nuclear Reactions	Interaction of charged particles with matter, Cross section, fission, Fission process; Energy release in Fission; Chain reaction; Nuclear fusion.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 5 th (10)	Introduction to nuclear physics
	6 th – 8 th (6)	Radioactive decay
	9 th - 10 th (4)	Interaction of radiation with matter
	11 th - 12 th (4)	Nuclear Reactions
	13 th -14 th (4)	Nuclear structure
	5 th	1 st In course Examination
	11 th	2 nd In course Examination

Recommended Readings

- Elements of Nuclear Physics, Walter E. Meyerhof, McGraw-Hill, ISBN 0-07-100221-9
- Fundamentals of Nuclear Science and Engineering, J. Kenneth Shultis, Richard E. Faw, ISBN: 0-8247-0834-2, 2002.
- Nuclear Physics, S.N. Ghoshal, 4th edition, 2010, ISBN: 81-219-0413-7
- Krane, Kenneth S. *Introductory Nuclear Physics*. 3rd ed. John Wiley & Sons, 1987. ISBN: 9780471805533.
- Introduction to Nuclear Engineering, John R. Lamarsh, Anthony J. Baratta, Third Edition, Chapter 4, ISBN 0-201-82498-1.
- Griffiths, David J. *Introduction to Quantum Mechanics*. 2nd ed. Addison-Wesley, 2004. ISBN: 9780131118928.

Course Title: General and Radiochemistry Lab**Course Code: NE-1204****Credit Hour: 1.5****Course description**

This course is designed to enable the students to achieve an in-general conceptual knowledge of chemistry and understand the application of chemical property in nuclear technology. The course mainly focuses on the different aspects of atom, atomic configuration, acid base relationship and thermo-chemistry. Analysis of nuclear decay kinetics will help students to understand basic mechanism of nuclear reaction. The students are expected to have the conceptual basics of chemistry, Daltons law etc.

Learning Outcome

Students will gain an understanding of:

- Students will acquire a minimum knowledge about the chemistry lab, kind of experiments that can be performed and the precautions to perform four types titrations and understand the principle involved in the applications of the method
- Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
- Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health.

List of Experiments

Expt. No.	Experiment Name
1	1. Standardization of a given HCl solution with Standard Na_2CO_3 solution and determination of Na_2CO_3 content in a sample of washing soda.
2	2. Standardization of a given thiosulphate solution with standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution and determination of copper content in a supplied sample solution by iodometric method.
3	3. Determination of total iron content in a compound by titrating against standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution.
4	4. Determination of the energy changes involved in a chemical reaction.
5	5. Determination of the enthalpy change for the decomposition of sodium bicarbonate into sodium carbonate by calorimetry.
6	6. Determination of the pH-neutralization curve of a strong acid by a strong base.

7	Spectrophotometric determination of iron from unknown sample
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Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week(Class)	
1	1st to 12th	Experiment
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- JP Adloff & R Guillaumont. Fundamentals of Radiochemistry. CRC Press, Boca Raton, 1993.
- KH Lieser, Nuclear and Radiochemistry, 2nd revised ed., Wiley-VCH, Berlin, 2001.
- WD Ehman & DE Vance. Radiochemistry and Nuclear Methods of Analysis. Wiley Interscience, New York, 1991.
- MF L'Annunziata, ed. Handbook of Radioactivity Analysis, 2nd ed., Academic Press, Amsterdam, 2003.
- G Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, Introduction of Nuclear and Radiochemistry, 3rd Edition, John Wiley (1981).
- General Chemistry, D. D. Ebbing, 6th Edition, Cengage Learning, 1999. ISBN: 9780395925508.
- Chemical Principles: The Quest for Insight, Atkins, Peter and Loretta Jones, 4th edition, New York, NY: W. H. Freeman and Company, 2007, ISBN: 9781429209656.
- Chemistry – The Molecular Nature of Matter and Change, M. Silberberg, 6th Edition, McGraw-Hill Education, 2011. ISBN: 9780073402659.
- Elementary Principles of Chemical Processes, R. M. Felder and R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2005. ISBN: 9780471697596.

Course Title: Differential and Integral Calculus

Course Code: NE-1205

Credit Hour: 3.0

Course Description

This course is designed to enable the students to achieve an in-general conceptual knowledge of calculus, one of the major sections of mathematics. Calculus is used in the core subjects of nuclear engineering including Reactor theory, radiation transport and shielding, thermal hydraulics, nuclear physics, instrumentation and control etc. This course will mainly focus on the two branches of calculus- differential calculus and integral calculus. Students are expected to understand the basics of calculus and develop the capability to apply calculus in nuclear engineering.

Learning outcomes

- After completing this course, the students should be able to:
- Understand the objective, definition and different aspects of calculus in nuclear application,
- Explain the basic calculus terms.
- Understand the theory of integral and differential calculus,
- Solve problems based on theoretical knowledge,
- Use the concepts in computer code, instrumentation and control (I&C) area, the heat transfer and fluid flow areas, neutron transport, shielding work, nuclear criticality, and nuclear safety etc. fields of nuclear engineering.

Course Syllabus

Topic	Contents
Functions and models	Functions, ways of representing a function, Catalogue of essential functions, New functions from old functions, Families of functions, Inverse functions, and Inverse trigonometric functions, exponential and logarithmic functions.
Limits and continuity	The limit of a function, Computing limits, precise definition of limit, Continuity, Limits at infinity, Horizontal asymptotes, Continuity of trigonometric, exponential and inverse functions, Parametric equations and Polar coordinates.
The derivatives	Tangent lines and rates of change, The derivative function, and introduction to techniques of differentiation, The product and quotient rules, Derivatives of trigonometric functions, The chain rule.
Differentiation rules	Implicit differentiation, Exponential growth and decay, Derivatives of logarithmic functions, Derivatives of exponential and inverse trigonometric functions, Related rates, Local linear approximation, Differentials, Hyperbolic functions, L'Hospital's rule, Indeterminate forms.
Applications of differentiation	Increase, decrease and concavity of functions, Absolute maximum and minimum values, Relative extrema, Graphing polynomials, Rational functions, Cusps and vertical tangents, Rectilinear motion, Newton's method, Rolle's theorem, The mean-value theorem.

Integration	The indefinite integral, Indefinite integrals and the net change theorem, Integration by substitution, The definition of area as a limit-sigma notation, The definite integral, Areas and distances, The substitution rule, Integration by parts, Trigonometric integrals, Trigonometric substitution, Integration of rational functions by partial fractions, Strategy for integration, Integration using tables and computer algebra systems, Approximate integration, Improper integrals, Logarithmic and other functions defined by integrals, Numerical integration, Simpson's rule.
Applications of integrals	Arc length, Area between two curves, Volume by slicing disks and washers, Volumes by cylindrical shells, Length of a plane curve, Area of a surface of revolution, Work, moments, centers of gravity and centroids, Fluid pressure and force, Hyperbolic functions and hanging cables.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In-course Examination	15
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st -2 nd (4)	Functions and models
	3 rd -4 th (4)	Limits and continuity
	5 th -6 th (4)	The derivatives
	7 th -8 th (4)	Differentiation rules
	9 th -11 th (6)	Applications of differentiation
	12 th -13 th (4)	Integration
	14 th (2)	Applications of integrals
	5th Week	1st in course examination
	11th Week	2nd in course examination

Recommended Readings

- Calculus: Early Transcendentals, James Stewart, 6th Edition, Thomson learning Inc., Belmont, CA 94002, USA, 2008.
- Calculus: Early Transcendentals, Howard Anton, IrlBivens and Stephen Davis, 10th Edition, John Willy & Sons, Inc., NJ 07030, USA, 2012.
- Calculus and Analytic Geometry, George B. Thomas and Ross L. Finney, 9th Edition, Addison-Wesley publishing company, Inc., USA, June 1998.

- University Calculus: Early Transcendentals, Joel Hass, Maurice D. Weir, George B. Thomas, 2nd Edition, Addison-Wesley, 2012. ISBN: 9780321753878.
- Thomas' Calculus: Global Edition /Matlab and Simulink Student Version 2012A, MathworksThe, George B. Thomas, Jr., Maurice D. Weir, Joel Hass, Frank R. Giordano, 12th Edition, Revised, Pearson Education, Limited, 2012. ISBN: 9781447935513.

Course Title: General and Radiochemistry

Course Code:NE-1207

Credit Hour: 3.0

Course Description

This course is designed to enable the students to achieve an in-general conceptual knowledge of chemistry and understand the application of chemical property in nuclear technology. The course mainly focuses on the different aspects of atom, atomic configuration, acid base relationship and thermo-chemistry. Analysis of nuclear decay kinetics will help students to understand basic mechanism of nuclear reaction. The students are expected to have the conceptual basics of chemistry, Daltons law etc.

Learning Outcomes

After completing this course, the students should be able to:

- Understand the objective, definition and different aspects of chemistry in nuclear application,
- Explain the basic chemical terms.
- Describe the acid base concept.
- Illustrate the knowledge of thermo chemistry and establish a relation with nuclear reaction.
- Understand the nuclear decay kinetics.
- Be familiar with the elements of radiochemistry
- Gain an idea on applications of radioisotopes and trans-uranium elements.

Course Syllabus

Topic	Contents
Introduction	Atom, atomic masses, atomic nucleus, Nuclear binding energy, nuclear stability, De Broglie's theory of matter, Standing waves and quantization, Quantum numbers, spin number, Pauli exclusion principles, atomic orbital's and their energies, shapes and orientation.
Acids and Bases	Brønsted-Lowry concept, Lewis concept, Acid - base strength, pH, Acid-base titration, indicators, Buffers, Henderson-Hasselbach equation, Hard and soft acids and bases.

Topic	Contents
Thermochemistry	Conservation of energy, Heats of reaction, enthalpy, enthalpies of formation, enthalpies of combustion, Hess's law, Radioactivity and the nature of atoms, Nuclear reaction vs. chemical reaction, types of nuclear reactions.
Nuclear Decay Kinetics	Transient and Secular Equilibrium, rates of radioactive decay
Elements of Radiation Chemistry	Interaction of ionizing radiation with matter, Units for measuring radiation absorption and radiation energy, Radiolysis of water and aqueous solutions, Chemical effects induced by nuclear reactions, Radiation damage induced core material property change, water or liquid metal side corrosion, corrosion in nuclear systems and design, Structural stability of metal or nonmetallic materials, Radiation hardening or embrittlement and swelling are studied and analyzed in terms of lattice defect interaction with energetic neutron, radiography and other isotopes for irradiators.
Applications of radioisotopes	Industrial vs. medical isotopes, General principles of using radioisotopes, Applications of radiotracers in Trace analysis of elements and compounds, Neutron activation analysis, isotope dilution analysis.
Trans-uranium elements	Uranium and plutonium compounds and their properties, Uranium extraction- Mining, milling, conversion, continuous solvent extraction process.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In-course Examination	15
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st -2 nd (4)	Introduction
	3 rd -4 th (4)	Acids and Bases
	5 th -6 th (4)	Thermochemistry
	7 th -8 th (4)	Nuclear Decay Kinetics
	9 th -11 th (6)	Elements of Radiation Chemistry
	12 th -13 th (4)	Applications of radioisotopes
	14 th (2)	Trans-uranium elements
	5th Week	1st in course examination
	11th Week	2nd in course examination

Recommended Readings

- JP Adloff & R Guillaumont. Fundamentals of Radiochemistry. CRC Press, Boca Raton, 1993.
- KH Lieser, Nuclear and Radiochemistry, 2nd revised ed., Wiley-VCH, Berlin, 2001.
- WD Ehman & DE Vance. Radiochemistry and Nuclear Methods of Analysis. Wiley Interscience, New York, 1991.
- MF L'Annunziata, ed. Handbook of Radioactivity Analysis, 2nd ed., Academic Press, Amsterdam, 2003.
- G Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, Introduction of Nuclear and Radiochemistry, 3rd Edition, John Wiley (1981).
- General Chemistry, D. D. Ebbing, 6th Edition, Cengage Learning, 1999. ISBN: 9780395925508.
- Chemical Principles: The Quest for Insight, Atkins, Peter and Loretta Jones, 4th edition, New York, NY: W. H. Freeman and Company, 2007, ISBN: 9781429209656.
- Chemistry – The Molecular Nature of Matter and Change, M. Silberberg, 6th Edition, McGraw-Hill Education, 2011. ISBN: 9780073402659.
- Elementary Principles of Chemical Processes, R. M. Felder and R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2005. ISBN: 9780471697596.

Course Title: Computer Programming-II

Course Code: NE-1209

Credit Hour: 3.0

Course Description

This course introduces the concepts of object-oriented programming to students with a background in the procedural paradigm. The course begins with a brief review of control structures and data types with emphasis on structured data types and array processing. It then moves on to introduce the object-oriented programming paradigm, focusing on the definition and use of classes along with the fundamentals of object-oriented design. Other topics include an overview of programming language principles, simple analysis of algorithms, basic searching and sorting techniques, event-driven programming, memory management and an introduction to software engineering issues.

Learning Outcomes

This course covers object-oriented programming principles and techniques using C++. Topics include pointers, classes, overloading, data abstraction, information hiding, encapsulation, inheritance, polymorphism, file processing, templates, exceptions, container classes, and low-level language features. This course also covers basic concepts for software design and reuse.

The students will learn

- Understand the features of C++ supporting object oriented programming.
- Understand the relative merits of C++ as an object oriented programming language.
- Understand advanced features of C++ specifically stream I/O, templates and operator overloading
- Use Eclipse as an Integrated Development Environment.
- Take a problem and develop the structures to represent objects and the algorithms to perform operations.
- Apply standards and principles to write truly readable code.
- Test a program and, if necessary, find mistakes in the program and correct them.
- Learn the fundamentals of input and output using the java.io library
- Design a class that serves as a program module or package.
- Understand and demonstrate the concepts of object-oriented design, polymorphism, information hiding, and inheritance.
- Use class library to develop projects involving several C++ files and class libraries.

Course Syllabus

Topic	Content
Introduction	Object oriented programming overview
Object Oriented Concepts	Modeling problems using object oriented concepts. Encapsulation, Inheritance and Polymorphism. Object Oriented vs. Procedural programming, Basics of Object Oriented Programming language.
Objects and Classes	Attributes and functions, constructors and destructors, functions or methods, overloading methods, access control, special considerations in different languages.
I/O	Stream and files. Inheritance: Inheriting classes, subclass, super class, access control, inheritance hierarchy, overriding, dynamic binding, abstract class, inner classes, special considerations in different languages, multiple inheritance, interface
Exception and exception handling	Exception handling fundamentals, exception types, chained exception, creating own exception subclasses. Designing Template Classes.
Package/Namespace	Understanding and implementing package/namespace.

Course Components

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Class Schedule

Class/week	Week (Classes)	Topic
2	1 st -2 nd (4)	Introduction
	3 rd -4 th (4)	Object Oriented Concepts
	5 th -7 th (6)	Objects and Classes
	8 th -11 th (8)	Inheritance
	12 th -13 th (4)	Exception and exception handling
	14 th (2)	Package/Namespace

Required and Recommended reading

1. Schildt, H, Teach Yourself C++, Tata McGraw-Hill Education, 1998. ISBN: 9780074638705.
2. Flanagan, David. Java™ in a Nutshell. 5th ed. Cambridge, MA: O'Reilly, 2005. ISBN: 0596007736.
3. Flanagan, David, and Brett McLaughlin. Java™ 1.5 Tiger: A Developer's Notebook. Cambridge, MA: O'Reilly, 2004. ISBN: 0596007388.
4. Schildt, H: Turbo C/C++: The complete reference, Second Edition, September 1st 1992 by Osborne Publishing, ISBN-10: 9780078817762.
5. N. Barkakati: Object Oriented Programming with C++, 1st edition, ISBN-10: 0672228009, Sams; 1st edition (July 1, 1991).
6. Balagurusamy, EISBN-10: 9352607996: Object Oriented Programming with C++, 7th Edition, McGraw Hill India; 7th edition (July 1, 2017).
7. B. Stroustrup: The C++ programming Language, 4th Edition, Addison-Wesley Professional; 4 edition (May 19, 2013), ISBN-10: 0321563840.
8. D. Ravichandran: Programming with C++, Programming With C++ 3rd Edition, ISBN-10: 0070681899.

Course Title: Sociology and Engineering Ethics

Course Code: NE 1211

Credit Hour: 3.0

Course Description

To understand the basic concepts in sociology and their fundamental theoretical interrelations, such that students will be able to define, give examples, show interrelationships, and demonstrate the relevance of the following:

- Understanding Sociology
- Society

- Socialization
- Sociological Research
- Culture
- Stratification
- Families and Intimate Relationships
- Economic Institutions
- Political Institutions
- Cities and Urban Life
- Science, the Environment, and Society
- Social Change and movements

Learning Outcome

- Master core concepts and methods from ecological and physical sciences and their application in environmental problem solving.
- Master core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.
- Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.

Course Syllabus

Topic	Contents
Understanding Sociology	Definition of Sociology, The Sociological Imagination, The Development of Sociology, Major Theoretical Perspectives, Taking Sociology with You
Society	Gerhard Lenski: Society and Technology, Hunting and Gathering Societies, Horticultural and Pastoral Societies, Agrarian Societies, Industrial Societies, Postindustrial Societies, Karl Marx: Conflict
Socialization	Nature Vs. Nurture, Theories of Socialization, Agents of Socialization, Life course and Re-socialization
Sociological Research	Scientific Method for Sociological Research, The Research Process, Research Methods
Culture	Definition of Culture, Elements of Culture- Symbols, - Language- Values and Beliefs, Norms, Cultural Diversity – Subculture - Multiculturalism- Counterculture - Cultural Change - Ethnocentrism and Cultural Relativism, Theories of Culture
Stratification	Systems of Social Stratification - Slavery, Caste, Estate, Class – Global –Super class, Social Class - Karl Marx - Max Weber, Maintaining Global Stratification – Neocolonialism - Multinational Corporations - Technology and Global Domination, Poverty and Mobility - The Underclass - Social Mobility- Types of Social Mobility

Topic	Contents
Families and Intimate Relationships	Basic Concepts of Family and Marriage, Change in Families and Partnership, Gender Inequality and 'dark side' of family, Theoretical Perspectives, The Transformation of Love and Intimacy
Economic Institutions	The Economy: Historical Overview, Economic Systems, Work in the Postindustrial U.S. Economy, Corporations
Political Institutions	Types of Authority, Types of Government, Perspectives on Politics, War and Terrorism
Cities and Urban Life	Theorizing Urbanism, The Development of the City - The Development of Modern City - Urbanization in the Developing World 3. Cities and Globalization - Global Cities - Cities and the Environment
Science, the Environment, and Society	Science and Society - Is Science a Social and Political Endeavor?, Agriculture and the Environment - Global Warming and Climate Change - Organic Food and Genetically Modified Organisms - Green Revolution, Biotechnology and the Human Genome, Computers and the Internet - Digital, Social, Global Divide
Social Change	Ethics: Science, environment, society

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st	Understanding Sociology
	2 nd	Society
	3 rd	Socialization
	4 th	Sociological Research
	5 th - 6 th	Culture
	7 th - 8 th	Stratification
	9 th	Families and Intimate Relationships
	10 th	Economic Institutions
	11 th	Political Institutions
	12 th	Cities and Urban Life
	13 th	Science, the Environment, and Society

	14 th	Social Change
	5 th	1 st In-course Examination
	10 th	2 nd In-course Examination

Recommended Readings

- Richard T. Schaefer. 2013. Sociology in Modules. 2nd edition New York, NY: McGraw-Hill.
- Anthony Giddens and Philip W. Sutton. 2013. Sociology. 7th edition New Delhi: Wiley.
- James M. Henslin. 2015. Sociology: A Down-to-Earth Approach. 11th ed. New Jersey: Pearson
- John. J. Macionis. 2012. Sociology. 14th ed. New Jersey: Pearson
- Dalton Conley. 2013. You May Ask Yourself. 3rd ed. New York: W.W. Norton & Company, Inc.
- Metta Spencer and Alex Inkeles. 1996. Foundations of Modern Sociology. Canada: Prentice Hall
- C. Calhoun, D. Light, S. Keller “Sociology” McGraw Hill, New York, 1997
- G. J. Bryjak & M. P. Soroka “Sociology”, Allyn & Bacon, 1997
- James Petras & Henry Veltmeyer “Globalization Unmasked”
- John J. Macionis: “Sociology” Pearson; 14 edition (October 6, 2011)
- Larry Siegel: “Criminology”, Cengage Learning; 15 edition (January 1, 2015),
- M.K. DeGenova & F. P. Rice: “Intimate Relationships, Marriages, & Families”
- Ken Brown “An Introduction to Sociology” Polity Press, USA, 1992

Some hand-out notes might also be given in the classes for further reading

SECOND YEAR FIRST SEMESTER:

Course Title: Fundamental of Electrical Engineering

Course Code: NE- 2101

Credit: 3.0

Course Description

This course is designed to facilitate the students to attain a thorough idea about fundamentals of electrical engineering. The course mostly focuses on the understanding of passive elements, network circuits and its analysis, networks theorems and the fundamentals of ac. This course also covers the topic of poly phase systems. Students are required to have the basic knowledge of electricity and magnetism in order to complete this course effectively.

Learning Outcomes

After completing this course, the students are expected to be able to

- Explain the fundamentals of electrical engineering.
- Discuss the laws of electric circuit and network theorems.
- Understand different type network circuits and their conversions, source conversion, the fundamental of DC, AC and phasors, the response of basic passive elements such as resistor, capacitor and inductors to both AC and DC.
- Analyze networks using network theorems.
- Be familiar with the poly phase system.
- Calculate current, voltage, resistance, capacitance, inductance, power, average values, RMS values, power factor etc.

Course Syllabus

Topic	Contents
Laws of electric circuit	Ohm's law, Kirchhoff's voltage and current laws
Basic passive elements	Resistor, Capacitor and Inductors in series and parallel, Transient in capacitive network, charging phase and discharging phase, transient in inductive network, storage and collapse phase, series-parallel RLC transient circuits
Network circuits and analysis	Fundamental electric concepts and measuring units, D.C. voltage, D.C current, resistance and power, dependent and independent sources, series-parallel circuits, open and short circuits, Star-Delta conversion
Networks theorems	Superposition theorem, Thevenins theorem, Nortons theorem, maximum power transfer theorem, Millman's theorem.
Fundamental of AC and the basic elements and phasors.	Generation of the ac voltage and current, the sine wave, general format of sinusoidal voltage and currents, phase and algebraic representation of sinusoids, average and RMS value, frequency response of the basic elements, average power and power factor, complex numbers, rectangular and polar form, series and parallel ac circuits, series-parallel ac circuits.
Poly phase Systems	The Three phase generator, The Y-connected generator, The Y-connected generator with a Y-connected Load, the Wye-Delta system, the Delta connected generator, the delta-delta, delta-Wye three phase systems, the three wattmeter method, the two wattmeter method, unbalanced three-phase, four wire, Y-connected load, Unbalanced three-phase, three wire Y-connected load

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class& circuit Simulation.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Class schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Laws of electric circuit
	2 nd – 3 rd (4)	Basic passive elements
	4 th – 5 th (4)	Network circuits and analysis
	6 th -8 th (6)	Networks theorems
	9 th -11 th (6)	Fundamental of AC and the basic elements and phasors.
	12 th -14 th (6)	Poly phase Systems
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended readings

- Introductory Circuit Analysis, 12th Edition, Robert L. Boylested, Pearson Education, 2010.
- Fundamentals of Electric Circuits, 5th Edition, Charles K. Alexander and Matthew N. O. Sadiku, McGraw-Hill Higher Education, 2013.
- Electrical and Electronic Principles and Technology, 3rd Edition, John Bird, Elsevier Ltd., Jordan Hill, Oxford, UK, 2007.
- Lesson's in Electrical Circuit, Tony R. Kuphaldt, 5th Edition, 2002.
- Introductory Circuitry for Electrical and Computer Engineering, James W. Nilsson and Susan A. Riedel, Prentice Hall, USA, 2011.
- Foundation of Analog and Digital Electronic Circuits, AnantAgarwal and Jeffrey H. Lang, Morgan Kaufmann Series, Elsevier Inc., San Francisco, USA, 2005

Course Title: Fundamentals of Electrical Engineering Lab

Course Code: NE–2102

Credit Hour: 1.5

Course Description

This course is designed to help the students to get a practical knowledge about the fundamentals of electrical engineering. The course mainly focuses on the practical knowledge of passive elements, network circuits and its analysis and networks theorems. This course also covers the topic of transient behavior of RC and RL circuits and electrical resonance.

Learning Outcome

- Explain the outcome of the experiments.
- Perform and measure the basic electric circuit experiment with the knowledge of fundamental laws.
- Analyze and assemble the diode and transistor circuit.
- Demonstrate measuring of basic electrical values on electric circuit elements.

- Explain application of circuits and devices in realization of electric appliances, machines and systems

List of Experiments:

R1	Verification of voltage divider rule and Kirchhoff's voltage law (KVL).
R2	Verification of current divider rule and Kirchhoff's current law (KCL).
R3	Verification of superposition theorem.
R4	Verification of maximum power transfer theorem.
R5	Verification of Thevenin's theorem.
R6	Verification of Norton's theorem.
R7	Verification of source conversion.
R8	To study the transient behavior of an RC circuit and time constant measurement.
R9	To study the transient behavior of an RL circuit and time constant measurement.
R10	Study of electrical resonance.
R11	To study RC high-pass and low-pass filters.
R12	To study RC band-pass filter.

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week (Classes)	Experiment
1	1 st	R1
	2 nd	R2
	3 rd	R3
	4 th	R4
	5 th	R5
	6 th	R6
	7 th	R7
	8 th	R8

	9 th	R9
	10 th	R10
	11 th	R11
	12 th	R12
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Introductory Circuit Analysis, 12th Edition, Robert L. Boylested, Pearson Education, 2010.
- Fundamentals of Electric Circuits, 5th Edition, Charles K. Alexander and Matthew N. O. Sadiku, McGraw-Hill Higher Education, 2013.
- Electrical and Electronic Principles and Technology, 3rd Edition, John Bird, Elsevier Ltd., Jordan Hill, Oxford, UK, 2007.
- Lesson's in Electrical Circuit, Tony R. Kuphaldt, 5th Edition, 2002.
- Introductory Circuitry for Electrical and Computer Engineering, James W. Nilsson and Susan A. Riedel, Prentice Hall, USA, 2011.
- Foundation of Analog and Digital Electronic Circuits, AnantAgarwal and Jeffrey H. Lang, Morgan Kaufmann Series, Elsevier Inc., San Francisco, USA, 2005

Course Title: Ordinary and Partial Differential Equations

Course Code: 2103

Credit Hour: 3.0

Course Description

This course is designed to enable the students to achieve an in-general conceptual knowledge of differential equations and understand the application of differential equations in nuclear engineering. Differential Equations are the language in which the laws of nature are expressed. Understanding properties of solutions of differential equations is fundamental to much of contemporary science and engineering. Ordinary differential equations (ODE's) deal with functions of one variable, which can often be thought of as time and partial differential equations deal with multiple variables. The students are expected to have the conceptual basics of ordinary and differential equations, Laplace transformation etc.

Learning outcomes

After completing this course, the students should be able to:

- Understand the objective, definition and different types of differential equations
- Explain the basic terms.
- Describe different methods of solving differential equations.
- Illustrate the knowledge of differential calculus to solve various problems of engineering.
- Understand the series solutions.
- Be familiar with systems of differential equations
- Gain an idea on applications of differential equations in nuclear field.

Course Syllabus

Topic	Contents
Differential Equations and Their Solutions	Concepts of variables parameter etc. Classifications of differential equations Methods of solution Initial value problem, Boundary value problems
First Order Differential Equations	Exact differential equations and Integrating factor, Separable equations and their solving methods, Linear and Bernoulli equations, Differences between linear and nonlinear equations, Numerical approximations: Euler's method
Second and Higher Order Differential Equations	Homogeneous and no-homogeneous equations, Reduction of order, Undetermined coefficient methods, Variation of Parameter, Cauchy-Euler Equations
Series Solutions of Linear Equations	Review of power series, series solutions near an ordinary point, Euler equations, regular singular points, Series solutions near a regular singular point, Bessel's equation, Convergence and Divergence Series.
Systems of First Order Linear Equations	Differential Operators, Linear system in normal form, Homogeneous linear systems with constant coefficients, Review of matrices, linear algebraic, equations; linear independence, eigen values, eigenvectors, Nonhomogeneous linear systems
Application of Differential Equations	Orthogonal and Oblique trajectories, Problems in Mechanics, Vibration of mass on spring, Free, damped motion, Forced motion, Electric circuit problems, Problems in nuclear sectors
Approximate methods of solving 1 st order Equations	Graphical methods, Power Series Methods, Successive approximation methods, Numerical methods

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In-course Examination	15
Semester Final Examination	70

Course Schedule

Class/week	Week (Classes)	Topic
2	1st (2)	Differential Equations and Their Solutions
	2nd -4th (6)	First Order Differential Equations

Class/week	Week (Classes)	Topic
	5th-7th (6)	Second and Higher Order Differential Equations
	8th (2)	Series Solutions of Linear Equations
	9th-10th (4)	Systems of First Order Linear Equations
	11th-13th (6)	Application of Differential Equations
	14th (2)	Approximate methods of solving 1st order Equations
	5th Week	1st in course examination
	11th Week	2nd in course examination

Recommended Readings

- Differential Equations, 3rd Edition, Shepley L. Ross, John Wiley & Sons, Inc., USA, 2011
- Elementary Differential Equations and Boundary Value Problems, 9th Edition, William E. Boyce and Richard C. DiPrima, John Wiley & Sons, Inc., USA, 2009.
- Differential Equations: An Introduction to Modern Methods and Applications, 2nd Edition, James R. Brannan and William E. Boyce, John Wiley & Sons, Inc., USA, 2011.
- Elementary Differential Equations, 6th Edition, C. Henry Edwards, David E. Penney and David Calvis, Pearson Education, Inc., Upper Saddle River, New Jersey, USA, 2008.
- Differential Equations: Crash Course, Richard Bronson and Erin J. Bredensteiner, Schaum's Outline Series, The McGraw-Hill Companies, Inc., USA, 2003.
- Differential Equation Demystified: A Self Teaching Guide, Steven G. Krantz, Demystified Series, The McGraw-Hill Companies, Inc., USA, 2005.

Course Title: Applications to Thermal Engineering Lab

Course code: NE-2104

Credit: 1.5

Course description:

Learning Outcomes:

The objective of the thermal engineering laboratory is to introduce the student the fundamental theories and the industrial applications of thermodynamics, heat transfer, and fluid mechanics. This laboratory supports the courses for the undergraduate and graduate studies. Moreover, this laboratory also supports the advanced research in the area of thermal engineering, heat transfer, and fluid mechanics.

List of Experiments:

1. Verification of Fourier Law of Heat Conduction Considering Linear Heat Transfer in a Cylinder
2. Verification of Fourier Law of Heat Conduction Considering Radial Heat Transfer in a Cylinder

3. Thermal Conductivity Measurement of Different Materials
4. Flow Rate Measurement using Venturi meter, Orifice meter and Rotameter
5. Verification of Bernoulli's theorem

Course Components (Learning Activities)

Experiments, Data collection, Data analysis, Report writing, Viva-voce.

Assessment Type:

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course Schedule:

One class 3-hour duration per week. Total number of classes will be 14 weeks in one semester.

Recommended Books:

- Yunus A. Cengel, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
- Holman J.P, Heat Transfer, Tata McGraw Hill, 2002.
- Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
- Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
- Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002

Course Title: Applications to Thermal Engineering

Course Code: NE- 2105

Credit:3.0

Course Description

This course is designed to facilitate the students a thorough idea about thermal engineering required in many industries. The objective of this course is to establish basic fundamental and practical knowledge in the field of steam power cycles and gas power cycles, internal combustion engines, industrial refrigeration, air conditioning, air compressor, fuels and combustions, etc.

Specific Objectives

- Understanding the basic concept and thermal performances from Carnot cycles to steam power cycles and gas power cycles for power generations.
- Understanding from basic to deepen concept and working of Fuels and Combustions, Gas Power Cycles and Internal Combustion Engines.
- Understanding from basic to deepen concept and working of refrigerator, air conditioning and heat exchange equipment

Learning Outcomes

After completing this course, the students are expected to be able to

- Analyze the performances of vapor power (Rankine) cycles, Gas power (Brayton) cycles and Combined power cycles for power generations
- Study and performance analyses of steam generators and heat exchangers for energy transfer
- Analyze performance of Internal Combustion Engine (ICEs) by operating them and observing changes in thermodynamic properties during each stroke of ICEs (and by using thermodynamic diagrams.)
- List characteristics and properties of fuels used for power generation and engines
- Analyze the performance of various refrigeration systems by operating them and observing the changes in properties of refrigerant during each process (and using thermodynamic charts/diagrams.)
- Explain the working concept of various air-conditioning equipment and their auxiliary equipment including ducts, fans and compressors

Course Syllabus

Topic	Content
Fuels	Classification of fuels, calorific value of fuels, Combustion of fuels.
Vapor Power and Gas Power Cycles	Carnot cycles, Otto cycles, Diesel cycles, Joule cycles (open and close), Properties of steam, Quality of steam, Rankin cycles, Thermal power plants and their components, Steam turbine, Gas turbine and their comparisons, Steam generator; water tube boiler, fire tube boiler, Steam generator's mounting and accessories; Steam generator performances, selections of boiler
IC Engines	Main components of IC engines, sequence of operations in a cycle, two stroke and four stroke cycle engines, valve timing diagram, cooling of IC engines, supercharging of IC engine, lubrication of IC engines, methods of governing of IC engines,
IC engines	Main components of IC engines, sequence of operations in a cycle, two stroke and four stroke cycle engines, valve timing diagram, cooling of IC engines, supercharging of IC engine, lubrication of IC engines, methods of governing of IC engines,
Air compressors	Types of air compressors, working principles of compressors, performance of compressors, Design of Condensers, Evaporators, Cooling towers, and Heat exchangers
Industrial refrigeration system	Properties of refrigerants, types of refrigerants, types of refrigeration cycles and Air conditioning

Course Component (Learning Activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Class schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Fuels and Combustions, Calorific values of fuels
	2 nd – 3 rd (6)	Carnot cycles, Vapor power(Rankine) cycles, Problems based on Rankin cycles, Steam generators, Accessories and Mountings.
	4 th – 5 th (6)	Gas power(Brayton) cycles, Problems based on Brayton cycles Combined power cycles, Gas power cycles in aerospace engineering.
	6 th -8 th (6)	Internal Combustion Engines, Otto Cycles, Diesel cycles, Starling cycles and their performances.
	9 th -11 th (4)	Condensers, Cooling towers and Heat exchangers and their thermal performances.
	12 th -14 th (4)	Refrigeration and air conditioning and their applications
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Reading

- Mahesh M. Rathore, Thermal Engineering, Tata McGraw-Hill Education, 2010.
- YunusA.Cengel, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
- V.P.Vasandani and D.S. Kumar, Treatise On Heat Engineering In MKS And SI Units, 4/eHolman.J.P, Heat Transfer, Tata McGraw Hill, 2002.
- Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
- Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002.
- Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004 Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
- T.R. Banga, S.C. Sharma, T. Manghnani, Mechanical Engineering Handbook, Khanna Publishers.

Course Title: Elements in Fluid Mechanics and Machinery**Course Code: NE-2107****Credit Hour: 3.0****Course Description**

This course is designed to facilitate the students to acquire a thorough idea of fluid mechanics and hydraulic machines. The course mostly focuses on different type of flow and flow patterns. Special attentions are given in the kinematic flow, viscous flow and buoyancy. The course also covers description of various hydraulic machines like turbine, centrifugal pumps, reciprocating pumps etc. The students should have a basic knowledge of differential

equations, equation of motions, and Newton's law of motion (fluid) to complete this course effectively.

Learning Outcomes

After completing this course the students should be able to

- Understand different type of fluid flows and their behavior.
- Learn how different manometers are used for measuring pressure and head loss.
- Learn about buoyant force and mathematically determine the metacenter for different geometry.
- Understand the continuity equation, Bernoulli's equation and their application.
- Learn different numbers used in hydraulics and their significance.
- Understand how friction plays a significant role in fluid flow.
- Understand how different type of fluid device works and their mechanism.
- Learn how hydraulic instruments work.

Course Syllabus

Topic	Contents
Properties of Fluids	Fundamental concept of fluid as a continuum, Viscosity, Thermodynamic properties, compressibility and bulk modulus, surface tension and capillarity.
Pressure and its measurement	Fluid pressure at a point, Pascal's law, pressure variation in a fluid at rest, types of pressure, measurement of pressure, simple manometers, differential manometers, pressure at a point in compressible fluid.
Hydrostatic Forces on Surfaces	Centre of pressure, Vertical plane surface sub-merged in liquid, Horizontal plane sub-merged in liquid, curved surface sub-merged in liquid.
Buoyancy and Flotation	Buoyancy, centre of buoyancy, meta-centre, meta-centric height, Analytical method for meta-centre height, conditions of equilibrium of a floating and sub-merged body.
Kinematics of Flow and Ideal Flow	Types of fluid flow, continuity equation, continuity equation in three dimension, velocity potential and stream function, types of motion, vortex flow.
Dynamics of fluid flow	Euler's equation, Bernoulli's equation.
Notches and Weirs	Discharge over a rectangular, triangular, and trapezoidal Notch or weir.
Orifices and mouthpieces	Classification of Orifices, flow through an orifice and a mouthpiece, hydraulic coefficients, flow through large orifice, flow through a convergent-divergent mouthpiece.
Viscous flow	Flow of viscous fluid through circular pipe, Flow of viscous fluid between two parallel plates, kinetic energy correction and momentum.

Turbulent flow	Frictional loss in pipe flow.
Flow through pipe	Loss of energy in pipes, loss of energy due to friction, Minor energy losses.
Hydraulic machines	Turbine, Centrifugal pumps, Reciprocating pumps, Fans, and Blowers.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class&Operating Training
Using Plant Simulators

Assessment Type

Activities	Percentage (%)
Class Attendance	5
Sudden Test	5
Class Test	5
In-course Examination	15
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 5 th (10)	Properties of fluid, pressure and its measurement, hydrostatic forces on surfaces
	6 th – 7 th (4)	Kinematic flow and Ideal flow
	8 th – 9 th (4)	Dynamics of fluid flow
	10 th -11 th (4)	Notch and weirs, orifice and mouthpiece
	12 th (2)	Viscous Flow, Turbulent flow
	13 th (2)	Flow through pipe
	14 th (2)	Hydraulic machines
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Victor L. Streeter, Fluid Mechanics, Mcgraw-Hill Book Company
- Dr. R.K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines(SI units), Pearson
- R S Khurmi, A Text Book of Engineering Mechanics(SI units), S Chand & Company Ltd

Course Title: Reactor Theory and Analysis**Course Code: NE-2109****Credit Hour: 3.0****Course Description**

An introductory course in nuclear reactor theory, which introduces students to the scientific principles of nuclear fission chain reactions and lays a foundation for the application of these principles to the nuclear design and analysis of reactor cores. It will focus on neutron transport methods, neutron diffusion and slowing down, criticality analyses for homogeneous and heterogeneous systems, reactor kinetics and control, reactivity coefficients, reactor systems and types, reactor design and reactor safety.

Learning Outcomes

After completing this course the students should be able to

- Be able to calculate neutron interaction probabilities.
- Demonstrate setup and solution of the diffusion equation in different geometries.
- Demonstrate calculations of the multiplication factor in one and two groups.
- Demonstrate calculations for numerical solution of the diffusion equation.
- Be able to solve the neutron slowing down equation.
- Demonstrate calculations of resonance integrals and resonance escape probabilities.
- Be able to solve the time dependent neutron equation.
- Be able to write and use solutions of the point kinetic equations.
- Demonstrate understanding of basic concepts in heterogeneous systems.
- Can understand reactivity coefficients measurement and calculations

Course syllabus

Topic	Contents
Review of the basic of neutron interactions	Possible type of interactions, consequences of these interaction, interaction probability, microscopic and macroscopic cross sections, cross-section systematics, cross-section data, prompt and delayed neutrons, reactor poisoning.
Slowing-down of neutrons	Elastic scattering mechanics, energy loss, average logarithmic energy decrement, slowing-down time, effect of inelastic scattering, collision and slowing-down densities, resonance absorption.
Neutron spectra	Thermal equilibrium, typical neutron spectrum in thermal and fast reactors, effective spectrum averaged cross-sections, resonance integrals.
Neutron life cycle	Four factor formula, fast fission factor, resonance escape probability, thermal utilization factor, Reproduction factor, effective multiplication factor, six factor formula
Introduction to neutron transport & diffusion	Neutron flux and current, derivation of the neutron transport equation, fundamental properties of the neutron transport equation, Fick's law, transport corrections, the diffusion equation for mono energetic neutrons, boundary conditions, elementary solutions of the steady-state diffusion equation, solutions for multiplying media, multi-group diffusion equations,

theory	solution of the two-group diffusion equation.
Nuclear reactor theory	One-group reactor equation, calculation of multiplication factor for a homogeneous and heterogeneous thermal reactor, criticality conditions, effect of reflectors, determination of critical concentration, dimension and mass, heterogeneity effects: fuel lumping and control-absorber lumping, calculation of thermal utilization, resonance escape probability, and fast fission factor, core properties during lifetime, fission products poisoning.
Reactivity variations in operating reactors	Effects of fuel and coolant temperature change, effect of coolant voiding, void coefficient, effect of fission products, effect of fuel depletion, BOL excess reactivity requirements for different reactor types.

Course Components (Learning activities)

Lecture, Discussion, Assignment, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 th (4)	Review of the basic of neutron interactions
	3 rd – 4 th (4)	Slowing-down of neutrons
	5 th (2)	Neutron spectra
	6 th (2)	Neutron life cycle
	7 th – 9 th (6)	Introduction to neutron transport & diffusion theory
	10 th -12 th (6)	Nuclear reactor theory
	13 th -14 th (4)	Reactivity variations in operating reactors
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- S.E. Liverhant., “Elementary introduction to nuclear reactor physics”. Second edition
- DOE fundamentals Handbook., Nuclear physics and reactor theory. Volume 1 and 2.

- Lamarsh, John R., and Anthony J. Baratta. Introduction to Nuclear Engineering. 3rd ed. Englewood Cliffs, NJ: Prentice Hall, 2001. ISBN: 9780201824988.
- T. Jevremovic, Nuclear Principles in Engineering, 2nd Edition, Springer 2009, ISBN: 978-0-387-85607-0.
- A.H. Foderaro, The Elements of Neutron Interaction Theory, MIT Press, 1971, ISBN-13: 9780262561600.
- Lewis, Elmer E. Fundamentals of Nuclear Reactor Physics. Burlington, MA: Academic Press, 2008. ISBN: 9780123706317.
- Duderstadt, James J., and Louis J. Hamilton. Nuclear Reactor Analysis. 1st ed. New York: Wiley, 1976. ISBN: 9780471223634.
- C. E. Iliffe, An Introduction to Nuclear Reactor Theory, Illustrated Edition, Manchester University Press, 1984, ISBN: 9780719009532.
- Introduction to Nuclear Reactor Theory, John R. Lamarsh, New York University.

Course Title: Principles of Accounting

Course Code: NE-2111

Credit Hour: 3.0

Course Description

The objective of this course is to develop students' understanding of basic concepts of accounting, accounting process, and the application of the conceptual framework in such process in order to develop their abilities to complete the accounting cycle ending with preparation and presentation of financial statements. This course will also try to equip the students with the knowledge and ability to understand and analyses the information communicated through the Financial Statements.

Learning Outcome

After completing this course the students should be able to

- Develop and understand the nature and purpose of financial statements in relationship to decision making.
- Develop the ability to use the fundamental accounting equation to analyze the effect of business transactions on an organization's accounting records and financial statements.
- Develop the ability to use a basic accounting system to create (record, classify, and summarize) the data needed to solve a variety of business problems.
- Develop the ability to use accounting concepts, principles, and frameworks to analyze and effectively communicate information to a variety of audiences.
- Develop the ability to use accounting information to solve a variety of business problems.
- Develop the ability to interact well with team members.

Course Syllabus

Topic	Contents
Introduction to Accounting	Definition of Accounting; Purpose and Nature of Accounting Information; Uses and Users of Accounting Information; Branches of Accounting; Nature of Business and Accounting; Role of Accountancy Profession
Accounting Process and Accounting Cycle	Accounting Equation; Effects of Transactions on the Accounting Equation; Double-Entry Accounting System; Accounting Cycle: Documentary Evidence and Identification, Journalization, Posting to the Ledger, Preparation of Trial Balance, Limitations of Trial Balance, Errors and their Rectification, Adjustments, Need for Adjustments, Adjusted Trial Balance, Preparation of Financial Statements, Closing Entries, Post-Closing Trial Balance; Preparation of Work Sheet and Reversing Entries. Guideline for Processing in Accounting: The Conceptual Framework of Accounting, The Objective of General Purpose Financial Reporting, The Reporting Entity, Qualitative Characteristics of Useful Financial Information, Underlying Assumptions, The Elements of Financial Statements, Recognition of the Elements of Financial Statements, Measurement of the Elements of Financial Statements, Concepts of Capital and Capital Maintenance.
Accounting for Merchandising Concern	Nature of the Inventories; Measurement of Inventories; Accounting for Merchandizing Operation; Using Mark-Up/Margin Percentages to Determine Costs; Writing off Inventories and Inventory Drawings. Preparation of Financial Statements: Statement of Comprehensive Income, Importance of Statement of Comprehensive Income, Limitations of Statement of Comprehensive Income, Preparation of Statement of Comprehensive Income, Single-Step and Multiple-Step Statement of Financial Position, Usefulness of Statement of Financial Position, Limitations of Statement of Financial Position, Preparation of Statement of Financial Position, Statement of Changes in Equity.
Capital Budgeting and Investment Appraisal	Overview of Capital Budgeting; Methods of Evaluation of Mutually Exclusive Projects; Investment Appraisal Techniques: Merits and Demerits, Ranking of Different Investment Appraisal Techniques; Use of Relevant Cash Flows in Investment Appraisal; Effect of Inflation; Replacement Analysis; Capital Rationing; Investment Appraisal in a Strategic Context.
Cost Concepts, Classification and Preparation of Cost Sheets	Concepts of Asset, Cost, Expense, and Loss; Classification of Costs; Cost Centre and Cost Unit; Cost Object; Cost Accounting Cycle; Factory Cost Flow; Statement of Cost of Goods Manufactured and Sold; Income Statement, CVP Analysis
Relevant Costing, Standard Costing and Variance	Meaning; Purposes of Standard Costs; Advantages of Standard Cost System; Fixation of Standards; Consideration in Establishing Standard; Types of Standards; Calculation of Variances: Material Price and Usage Variances, Labor Rate and Efficiency Variances, Overhead Volume and Spending Variances; Recording Journal

Topic	Contents
Analysis	Entries Under the Standard Costing System; Performance Report
Process Costing and Cost Allocation: Joint Products and By-Products	Nature of Process Costing; Similarities and Dissimilarities between Job Order Costing and Process Costing; Physical Flow; Flow of Costs; Elements of Process Costs (Material, Labor, Factory Overhead, and Transferred-in Costs); Methods of Determining and Accounting for Cost Flows (Weighted Average vs. FIFO); Equivalent Units of Production; Cost of Production Report; Journal Entries Using Process Costing; Accounting for Normal Loss, Abnormal Loss, Abnormal Gain and Scrap. Basic Concepts: Joint Products and By Products, Common Costs and Joint Costs, Split Off Point and Separable Costs; Allocation of Joint Costs; Assignment of Costs to Joint Products: Market Based Approach and Physical Measurement; Irrelevance of Joint Costs for Decision Making; Accounting for By-Products: Production Method and Sales Method; Journal Entries for By-Products

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 5 th (10)	Introduction to Accounting, Accounting Process and Accounting Cycle
	6 th – 7 th (4)	Accounting for Merchandising Concern
	8 th – 9 th (4)	Basic Ideas on Financial Statement Analysis
	10 th -11 th (4)	Capital Budgeting and Investment Appraisal
	12 th (2)	Cost Concepts, Classification and Preparation of Cost Sheets
	13 th (2)	Relevant Costing, Standard Costing and Variance Analysis
	14 th (2)	Process Costing and Cost Allocation: Joint Products and By-Products

Class/week	Date: Week (Classes)	Topic
	5 th	1 st In course Examination
	11 th	2 nd In course Examination

Recommended Readings

- Jerry J. Weygandt, Paul D. Kimmel and Donald E. Kieso. *Accounting Principles*, John Wiley & Sons, Inc.
- L. G. Rayburn. *Cost Accounting: Using a Cost Management Approach* (IRWIN).
- C. T. Horngren, G. Foster and S. M. Datar. *Cost Accounting: A Managerial Emphasis*, Prentice Hall
- D. R. Hansen and M. M. Mowen. *Cost Management: Accounting and Control*, South-Western Publishing Co.
- S. P. Iyengar. *Cost Accounting: Principles and Practice*, Sultan Chand & Sons
- Ralph S. Polimeni, Frank J. Fabozzi and Arthur H. Adelberg. *Cost Accounting: Concepts and Applications for Managerial Decision Making*, McGraw-Hill Inc.
- Milton F. Usry and Lawrence H. Hammer. *Cost Accounting: Planning & Control*, (South-Western Publishing Co.

SECOND YEAR SECOND SEMESTER:

Course Title: Electronics –I (Analog Electronics)

Course Code: NE- 2201

Credit Hour: 3.0

Course Description

This course is designed to provide the students a clear idea about analog electronics and its applications. The course mostly focuses on the band theory of solids; construction, operation, characteristics and application of semiconductor diodes, bipolar junction transistor (BJT) and field effect transistor (FET). The course also covers the topic of operational amplifiers and its applications. Students are required to have the basic knowledge of electrical circuits, atomic bond formation and calculus.

Learning Outcomes

After completing this course the students are expected to be able to

- Explain energy level and energy band diagrams of different materials; the formation, operations, characteristics and applications of various semiconductor diodes, BJT and FET.
- Discuss working principle of various analog electronic devices.
- Demonstrate characteristics of semiconductor diodes, BJT and FET.

- Understand the band theory of solids and also different configurations of BJT FET.
- Describe the operation of half-wave and full wave rectifier, voltage regulation, voltage-doublers, clippers and clamper.
- Be familiar with operational amplifiers and its applications.
- Calculate drift current, diode parameters using data sheets; emitter current, base current and collector current of BJT; gate, source and drain currents of FET, current and voltage gains for different BJT configurations etc.
- Analyze diode circuit using load line analysis; design half-wave and full wave rectifier, voltage regulator, voltage doubler, clipper and clamper for any particular operation.
- Construct non-inverting and inverting amplifiers, integrator, differentiator, weighted summer using operational amplifier.

Course Syllabus

Topic	Contents
Band Theory of solids	Energy band diagram of conductor, insulator and semiconductor, intrinsic and extrinsic semiconductor, effects of temperature on extrinsic semiconductors, Drift, Diffusion and other carrier theory.
Semiconductors diodes	P-N Junction Diode characteristics, the ideal diode and real diode, P-N junction diode as a circuit element, load Line analysis of a diode circuit, special diodes – Zener diodes, Schottky barrier diodes, varactor diodes, photo diodes, LED and tunnel diode, pin diode, half-wave and full wave rectifier, voltage regulation, voltage doublers, clippers and clamper.
Bipolar Junction Transistor (BJT)	PNP and NPN transistors, principles of operation, different configurations of transistor, relations between α and β , leakage current in a transistor, thermal runaway in a transistor, DC load line, Q-point, transistor biasing, effects on bias variations, stability factor for CB and CE Configurations, AC load Line, biasing and thermal stability, small signal analysis, π -model, T-model, equivalent circuits using transconductance parameter for low, medium and high frequency operation of BJT.
Field Effect Transistor (FET)	Construction of JFET and MOSFET, characteristics and principles of operation, FET biasing, small signal analysis, introduction to CMOS and its application. Application of FETs as amplifier and switches, load line analysis, equivalent circuits using trans conductance parameter for low, medium

	and high frequency operation of FETs, Ebers-Moll model view, design and analysis of single/multistage amplifiers, power amplifiers, differential amplifiers.
Operational amplifiers and applications	Linear application of op-amp, feedback, gain, input and output impedances, properties of an ideal op-amp, non-inverting and inverting amplifiers, integrator, differentiator, weighted summer and other applications of op-amp circuits, frequency response and bandwidth.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & Simulation.

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (4)	Band Theory of solids
	3 rd – 5 th (6)	Semiconductors diodes
	6 th – 9 th (8)	Bipolar Junction Transistor (BJT)
	10 th -12 th (6)	Field Effect Transistor (FET)
	13 th -14 th (4)	Operational amplifiers and applications
	5 th	1 st In-course Examination
	12 th	2 nd In-course Examination

Recommended Readings:

- Electronic Devices & Circuits, 5th Edition, David A. Bell, Oxford University Press, ISBN: 978-0195693409.
- Electronic Devices & Circuit Theory, 10th Edition, Robert L. Boylestad and Louis Nashelsky, Prentice Hall, Inc., New Jersey, USA, 2009.
- Microelectronic Circuits, 6th Edition, Adel S. Serda, Kenneth Carless Smith, Oxford University Press, Incorporated, 2010. ISBN: 9780195323030.

- Integrated Electronics: Analog and Digital Circuits and Systems, Jacob Millman, Christos C. Halkias, Tata McGraw-Hill Education, 1972. ISBN: 9780074622452.
- Op-amps and Linear Integrated Circuits, 4th Edition, Ramakant A. Gaykwad, Prentice Hall Inc., 2000.
- Operational Amplifiers and Linear ICs, 2nd Edition, David A. Bell, 1997. ISBN: 9780968250204.
- Operational Amplifiers and Linear Integrated Circuits, 6th Edition, Robert F. Coughlin, Frederick F. Driscoll, Prentice Hall, Pearson Education International, 2001. ISBN: 9780131224568.

Course Title: Electronics – I (Analog Electronics) Lab

Course Code: NE–2202

Credit Hour: 1.5

Course Description

This course is designed to help the students to get a practical experience in the field of analog electronics and its applications. The lab mostly focuses on the operation, characteristics and application of semiconductor diodes, bipolar junction transistor (BJT) and field effect transistor (FET). The course also covers the topic of operational amplifiers and its applications.

Learning Outcomes

- Acquire basic knowledge of physical and electrical conducting properties of semiconductors.
- Develop the Ability to understand the design and working of BJT / FET amplifiers.
- Able to design amplifier circuits using BJT s And FET's. and observe the amplitude and frequency responses of common amplifier circuits
- Observe the effect of positive feedback and able to design and working of different Oscillators using BJTS.
- Develop the skill to build, and troubleshoot Analog circuits.

List of Experiments:

R1	To study P-N junction diode characteristics.
R2	To study Zener diode characteristics.
R3	Verification of half wave and full-wave bridge rectifier circuit.
R4	Implementation and testing of diode clipping circuit.
R5	To study the input and output characteristics of a bipolar junction transistor in common base configuration.
R6	To study the input and output characteristics of a bipolar junction transistor in common emitter configuration.
R7	To study the I_D/V_{DS} Characteristics for an n-channel JFET.
R8	To study Inverting and Non Inverting Amp using Op-Amp.
R9	Implementation and testing of an Op-amp voltage follower circuit.
R10	Design and implementation of an Op-amp integrator circuit

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week	Experiment
1	1 st	R1
	2 nd	R2
	3 rd	R3
	4 th	R4
	5 th -6 th	R5
	7 th -8 th	R6
	9 th	R7
	10 th	R8
	11 th	R9
	12 th	R10
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Electronic Devices & Circuits, 5th Edition, David A. Bell, Oxford University Press, ISBN: 978-0195693409.
- Electronic Devices & Circuit Theory, 10th Edition, Robert L. Boylestad and Louis Nashelsky, Prentice Hall, Inc., New Jersey, USA, 2009.
- Microelectronic Circuits, 6th Edition, Adel S. Serda, Kenneth Carless Smith, Oxford University Press, Incorporated, 2010. ISBN: 9780195323030.
- Integrated Electronics: Analog and Digital Circuits and Systems, Jacob Millman, Christos C. Halkias, Tata McGraw-Hill Education, 1972. ISBN: 9780074622452.
- Op-amps and Linear Integrated Circuits, 4th Edition, Ramakant A. Gaykwad, Prentice Hall Inc., 2000.
- Operational Amplifiers and Linear ICs, 2nd Edition, David A. Bell, 1997. ISBN: 9780968250204.
- Operational Amplifiers and Linear Integrated Circuits, 6th Edition, Robert F. Coughlin, Frederick F. Driscoll, Prentice Hall, Pearson Education International, 2001. ISBN: 9780131224568.

Course Title: Radiation Science and Health Physics**Course Code: NE-2203****Credit: 3.0****Course Description**

This course is designed to facilitate the students to acquire a thorough idea of Radiation, different types of radiation interaction with matters. The course mostly focuses on various types of radiation detectors ionizing chamber, proportional & Geiger muller counters, scintillation detectors. Special attentions are given to Radiation protection standards, basic concepts on dosimetry, external internal exposure and different type of dose. The course also covers the circuits & equipment used in radiation detection. The students should have a basic knowledge of nuclear reactor, radiation science and physics in order to complete this course effectively.

Learning Outcomes

After completing this course the students should be able to

- Understand the interaction mechanism of different types of radiation.
- Explain the working principles of radiation detectors.
- Describe the basic electronic circuits and equipment used in radiation field.
- Illustrate the calculation of absorbed dose from external or internal exposure.
- Depict the nuclear regulatory commission regulations, health physics instrumentations and personal dosimetry.
- Be familiar with Bragg-grey cavity theory, the roentgen, free air ionization chamber, thimble, condenser, chambers, farmer chambers, electrometers, extrapolation chambers, parallel plate chambers, ion collection, chamber polarity effects, and measurement of exposure.

Course Syllabus

Topic	Contents
Introduction	Radiation sources, interaction of radiation with matter, basic principles of radiation detection, principles of radiation detectors and their common properties, various types of detectors, radiation spectroscopy.
Scintillation and ionization detector	Design aspects of ionization chambers, Proportional and Geiger-Muller counters, Various types of scintillators, Scintillation detectors, Radiation spectroscopy using Scintillation detectors, Semiconductors, Various types of semiconductor detectors and their characteristics, Neutron sources, Neutron detection techniques and neutron spectroscopy.
Radiation counting	Basic electronic circuits and electronic equipment used in nuclear radiation detection systems, measure of central tendency and dispersion, concepts of sample space, events, random variables and probability, probability distributions (discrete & continuous), curve fitting and tests for goodness of fit, errors and their propagation; counting statistics.
Dosimetry	Various types of dosimeters, basic concept of dosimetry, dose calibrator, collimation of radiation, radiation protection

	standards, basic principles for control of external and internal exposures and absorbed dose estimation, protection against radiation from brachytherapy sources, nuclear regulatory commission regulations, health physics instrumentation and personal dosimetry.
Measurement of ionizing radiation	The roentgen, free air ionization chamber, thimble, condenser, chambers, farmer chambers, electrometers, extrapolation chambers, parallel plate chambers, ion collection, chamber polarity effects, measurement of exposure.
Measurement and calculation of absorbed dose	Radiation absorbed dose, calculation of dose from exposure, the bragg-gray cavity theory, determination of absorbed dose in a medium using chamber as a bragg-gray cavity theory, transfer of absorbed dose from one medium to another, exposure from radioactive sources.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class etc.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 th (4)	Introduction
	3 th – 5 th (6)	Scintillation and ionization detector
	6 th – 8 th (6)	Radiation counting
	9 th -11 th (6)	Dosimetry
	12 th -13 th (3)	Measurement of ionizing radiation
	13 th -14 th (3)	Measurement and calculation of absorbed dose
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Edward L. Alpen, Radiation Biophysics, 2nd Edition, Academic Press (1998), ISBN: 9780080540207.
- Faiz M. Khan, The Physics of Radiation Therapy, 4th Edition, Lippincott Williams & Wilkins, 2012, ISBN: 9781451149135.
- James E. Turner, Atoms, Radiation, and Radiation Protection, John Wiley&Sons, Inc. (2008), ISBN: 9783527616985.
- Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons, 2008, ISBN: 9783527617142

- Marie Claire Cantone, Christoph Hoeschen, Radiation Physics for Nuclear Medicine, Illustrated Edition, Springer, 2011, ISBN: 9783642113277
- Ervin B. Podgorsak, Radiation Physics for Medical Physicists, Springer, 2010, ISBN: 9783642008757.
- Knoll G. F. Radiation Detection & Measurements, 3rd Ed., John Wiley, 2005.
- Lamarsh, J. R. Introduction to Nuclear Engineering, 3rd Edition, Addison-Wesley, 2001.
- Martin, A. and Harbison, An Introduction to Radiation Protection, 3rd Ed., Chapman & Hill, 1986.
- Sorenson, J.A. and Phelps, M.E. "Nuclear Counting Statistics in Physics and Nuclear Medicine", Grune & Stratton, 1980.
- Todreas, N. E. and M. S. Kazimi. *Nuclear Systems*. Vol. 2. New York, NY: Francis & Taylor, 1990. ISBN: 9781560320791.
- Cember. H. and Johnson. E. T. *Introduction to Health Physics*. 4th Ed.
- Shultis. K. J. and Faw. E. R. *Fundamentals of Nuclear Science and Engineering*.

Course Title: Radiation Sciences and Health Physics Lab

Course Code: NE-2204

Credit Hour: 1.5

Course Description

This course is designed to help the students to get a practical experience in the field of radiation science. The course mainly includes the study of radiation counter, counting statistics, determination of optimal operating voltage, Efficiency, resolving time of GM counter, absorption and scattering properties of different absorbers, attenuation behavior of different radiations, determination of various attenuation parameters and determination of radioisotope's Half-life.

Learning Objectives:

- To be familiar with GM counter and learn different application of it
- To investigate different aspects of absorber material, scattering material
- To understand the range, attenuation and energy of different radiation.
- To verify different laws in radiation fields

List of Experiments:

R1	Plotting a Geiger plateau curve. Hence to determine the optimal operating voltage of GM counter.
R2	To investigate the statistics related to measurements with a GM counter.

R3	To investigate background radiation using GM counter. Hence to determine the corrected counts from a radioactive source.
R4	To determine the resolving time of GM counter.
R5	To determine the efficiency of a Geiger-Muller counter for various types of radiation.
R6	To investigate (i) the relationship between absorber material and scattering and (ii) the relationship between absorber thickness and backscattering.
R7	To verify the inverse square law relationship between the distance and intensity of radiation.
R8	To determine the range of an alpha particle in air and hence the alpha particle's energy.
R9	To investigate the attenuation of radiation via the absorption of beta particles and hence to find the half value thickness of a radioactive material.
R10	To determine the maximum energy of decay of a beta particle.
R11	To investigate the attenuation of radiation via the absorption of gamma rays and hence to find the half value thickness of a radioactive material.
R12	To measure the half-life of metastable barium-137.

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week	Experiment
1	1 st	R1
	2 nd	R2
	3 rd	R3
	4 th	R4
	5 th	R5
	6 th	R6
	7 th	R7
	8 th	R8
	9 th	R9

	10 th	R10
	11 th	R11
	12 th	R12
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Introduction to Health Physics, Herman Cember and Thomas E. Johnson, 4th edition
- Radiation Detection and Measurement, G.F. Knoll, 3rd edition
- Spectrum Techniques, Lab Manual, student version, 2002
- Experiments with G.M. Counter, edited by J.N. Reddy & Dr. M.S.R Murty, Nucleonix Systems Private Limited.

Course Title: Vector Analysis and its Applications

Course Code: NE 2205

Credit Hour: 3.0

Course Description

Calculus is considered to be one of the greatest achievements of the human intellect and Vector Calculus is one of the major area of calculus. It is concerned with differentiation and integration of vector fields, primarily in 3-dimensional Euclidean space $\mathbb{R}^3$. It is used extensively in physics and engineering, especially in the description of electromagnetic fields, gravitational fields and fluid flow.

This course is designed to develop the intuitive understanding, theory, and computational skills necessary for the concepts of calculus of functions of several variables by tying together vector differential calculus with vector integral calculus. These functions are interesting in their own right, but they are also essential for describing the physical world. Through the use of the unifying themes of double integrals, triple integrals, line integrals and surface integrals, the course will become a cohesive whole rather than a collection of unrelated topics.

Learning Outcomes

By the end of the course students will know how to integrate functions of several variables and vector valued functions. In single variable calculus, the Fundamental Theorem of Calculus relates derivatives to integrals. We will see something similar in this course, namely, Green's Theorem, Stokes' Theorem and Gauss' Theorem and understanding the physical significance of these theorems will be the capstone of the course.

After completing this course, students should have developed a clear understanding of the fundamental concepts of multivariable integral and vector calculus and a range of skills allowing them to work effectively with the concepts.

The skills (learning outcomes) include:

- The ability to work with different types of coordinate systems like rectangular coordinates, cylindrical coordinates and spherical coordinates.
- The ability to understand and to sketch, roughly, different types of cylindrical and quadric surfaces.
- The students will be able to get the idea of vector valued functions and calculus of vector valued functions.
- The students will become familiar with unit tangent, normal, binormal, arc length and curvature.
- The ability to set up and compute multiple integrals in rectangular, polar, cylindrical and spherical coordinates.
- An understanding of physical significance of gradient, divergence and curl.
- An understanding of line integrals for work and flux, surface integrals for flux, general surface integrals and volume integrals. Also, an understanding of the physical interpretation of these integrals.

An understanding of the major theorems (Green's, Stokes', Gauss') of the course and of some physical applications of these theorems

Course Syllabus

Topic	Contents
Vectors and the geometry of space	Three-dimensional coordinate systems, vectors, the dot product, the cross product, equations of lines and planes, cylinders and quadric surfaces, cylindrical and spherical coordinates
Vector functions	Vector functions and space curves, derivatives and integrals of vector functions, arc length and curvature, motion in space: velocity and acceleration, planetary motion and satellite.
Vector calculus	Vector fields, line integrals, the fundamental theorem for line integrals, independence of path, conservative vector fields, Green's theorem, curl and divergence, parametric surfaces and their areas, surface integrals, applications of surface integrals, flux, Stokes' theorem, the divergence theorem
	Applications of Navier-Stokes' Equations, Stokes' Equations, Green's Theorems, Divergence theorem for solving engineering problems

Course Components

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Class Schedule

Date: Week (Classes)	Topic
1 st -2 nd (4)	Vectors and the geometry of space
3 rd -5 th (6)	Vector functions
6 th -7 th (4)	Multiple Integrals
8 th -10 th (6)	Vector calculus
13 th -14 th (4)	Applications

Recommended Readings

- H. Anton, I.C. Bivens and S. Davis, **Calculus: Early Transcendentals (10th Edition)**, Wiley.
- J. Stewart, **Calculus (6th Edition)**, Thomson Learning.
- R.T. Smith, R. B. Minton, **Calculus (4th Edition)**, McGrawHill
- R. Larson, B. H. Edwards, **Calculus: Early Transcendentals (5th Edition)**, Cengage Learning
- G.B. Thomas, M.D. Weir and J. Hass, **Thomas' Calculus (12th Edition)** Addison Wesley.

Course Title: Statistics for Engineers

Course Code: NE 2207

Credit Hour: 3.0

Course Description

Basic knowledge of statistics is essential for engineers in order to make reasonable decisions based on data.

Learning Outcome

This course gives a working knowledge and understanding of descriptive and inferential statistics and how statistics is applied in science and engineering.

Course Syllabus

Topic	Contents
Introduction	Definition of statistics; population and sample; descriptive and inferential statistics; parameter and statistic; variables - categorical, discrete and continuous; measurement scales - nominal, ordinal, interval and ratio.
Processing data	Frequency tables; graphs; histograms.
Summarizing data	Measures of central tendency, dispersion and skewness.
Correlation and regression	Pearson's correlation coefficient, simple and multiple linear regressions.
Probability	Axioms of probability; conditional probability; Bayes' theorem; independence of events.
Random variable	Probability distributions; joint, marginal and conditional distributions; independence of random variables.
Mathematical expectation	Expectations of discrete and continuous random variables and their functions.
Basic distributions	Binomial; Poisson; hyper geometric; uniform; exponential; normal.
Sampling distribution	Basic idea; distributions of mean and proportion.
Estimation	Point estimation; confidence intervals.

Course Components

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st -2 nd (4)	Introduction
	3 rd (2)	Processing data
	4 th (2)	Summarizing data
	5 th (2)	Correlation and regression

Class/week	Date: Week (Classes)	Topic
	6 th -7 th (4)	Probability
	8 th (2)	Random variable
	9 th -10 th (4)	Basic distributions
	11 th (2)	Sampling distribution
	12 th (2)	Estimation
	13 th -14 th (4)	Hypothesis testing

Recommended Readings

Ross, Sheldon. *Introduction to Probability and Statistics for Engineers and Scientists*. 5th Edition. Academic Press, 2014.

Course Title: Nuclear Fuel Cycle and Radioactive Waste Management

Course Code: NE-2209

Credit: 3.0

Course description

This course is designed to facilitate the students to acquire a thorough idea of Nuclear Fuel Cycle (both fission and fusion) and Radioactive Waste Management. The course mostly focuses on the different steps of front end and back end of the fission fuel cycle. Special attentions are given in the fuel cycle management of thermal and fast breeder Reactor. The course also covers advanced fuel cycle and fusion fuel cycle. The students should have a basic knowledge of nuclear reactor, radiation science and chemistry in order to complete this course effectively.

Learning outcomes

After completing this course the students should be able to

- Understand the different steps of fission fuel cycle, distinguish front end and back end of the cycle as well as open and close fuel cycle.
- Explain the various methods of uranium mining, milling, uranium purification and conversion, methods of enrichment.
- Describe the fabrication of fuel rod as well as fuel assembly and characteristics of the fuel assembly of different types of power reactors.
- Illustrate the material balance in the nuclear fuel cycle, different refueling methods, fuel cycle management in breeder reactors.

- Depict the sources and types of radioactive waste, different steps of radioactive waste management, steps of spent fuel management, decommissioning of nuclear facilities.
- Be familiar with Future fuel cycle i.e. Partitioning and transmutation (P & T) and also with Fusion fuel cycle.
- Calculate the feed of an enrichment plant, SWU, conversion ratio, breeding ratio, breeding gain, fuel burn up rate, consumption rate, annual fuel requirement of a NPP, heat generation from spent fuel, flow rate for spent fuel pool and transfer cask, heat generation from buried waste etc.

Course syllabus

Topic	Contents
Fission fuel cycle	Definition and different steps of Nuclear fuel cycle (NFC), types of NFC- Once through cycle (Direct disposal) & closed cycle (spent fuel reprocessing). Front End of the Fuel Cycle: Geochemistry of uranium, metallurgical classification of ore body, methods of uranium mining, milling process, solvent extraction of metals, uranium purification and conversion, methods of enrichment and fuel fabrication, different steps of back end of fuel cycle.
Fuel Utilization	Fuel cycle management in thermal reactor viz material balance in the nuclear fuel cycle, supply of uranium, nuclear fuel demand, nuclear fuel performance, different refueling methods, fuel cycle management in breeder reactors viz conversion ratio & breeding ratio, breeding gain, doubling time etc.
Future fuel cycle	Partitioning and transmutation (P&T), block diagram of advanced fuel cycle (AFC), transmutation devices for the AFC, components of accelerator driven system (ADS), P&T of high level waste by ADS, thorium fuel cycle.
Waste management	Radiation source, exposure & health effects, definition and characteristics of radioactive waste, source of radioactive waste, classification of radioactive waste, objectives and principles of radioactive waste management (RWM), different steps of RWM, product quality control of radioactive waste, regulatory requirements & methods of treatment, transportation, burial & surveillance of waste, composition of spent fuel, management and disposal of spent fuel & high level waste – sources, volume, treatment and storage, transuranic waste & environment restoration, mills tailings & mixed waste decontamination & decommissioning of nuclear facilities.
Fusion fuel cycle	Raw materials of the fusion process, synthesis of tritium, generation mechanism of plasmas, magnetic confinement of plasmas- Tokamak & Stellerator principle, source of fuel impurities, blanket materials, Potentiality of ITER project.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 5 th (10)	Fission fuel cycle
	6 th – 7 th (4)	Fuel Utilization
	8 th - 12 th (10)	Waste management
	13 th (2)	Future fuel cycle
	14 th (2)	Fusion fuel cycle
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Introduction to Nuclear Engineering, John R. Lamarsh, Anthony J. Baratta, Third Edition, Chapter 4, ISBN 0-201-82498-1.
- Nuclear Reactor Engineering, Glasstone and Sesonske, Third ed. Chapter 7
- Nuclear Engineering Handbook, Kenneth D. Kok, Section II, ISBN 978-1-4200-5390-6
- Introduction to Nuclear Power, Hewit& Collier, 2nded.
- Applied Reactor Technology, Henry Anglart, 2011, Chapter 7
- Benedict, M., T. H. Pigford, and H. W. Levi. *Nuclear Chemical Engineering*. 2nd ed. Chapter 3-5, Columbus, OH: McGraw-Hill, 1981. ISBN: 9780070045316.
- IAEA Series on Nuclear Fuel Cycle and Radioactive Waste Management.
- Mawson, G.A., Management of Radioactive Wastes, Van Nostrand, 1965.
- Peter D. Wilson, The Nuclear Fuel Cycle: From Ore to Wastes, illustrated, reprint edition Oxford University Press, 1996, ISBN: 9780198565406.
- Knief, R. A. *Nuclear Energy Technology*. 2nd ed. Miami, FL: Hemisphere Press, 1992. ISBN: 9780070350861
- Cochran R. G., and N. Tsoulfanidis. *The Nuclear Fuel Cycle: Analysis and Management*. 2nd ed. La Grange Park, IL: American Nuclear Society, 1993. ISBN: 9780894484513.
- Driscoll, M. J., T. J. Downar, and E. E. Pilat. *The Linear Reactivity Model for Nuclear Fuel Management*. La Grange Park, IL: American Nuclear Society, 1991. ISBN: 9780894480355.

- Levine, S. H. "Fuel Management." In *CRC Handbook of Nuclear Reactor Calculations*. Edited by Y. Ronan. Boca Raton, FL: CRC Press, 1987. ISBN: 9780849329272.
- Rasmussen, N. C., et al. *Nuclear Waste: Technologies for Separations and Transmutation*. Washington, DC: National Research Council, 1996. ISBN: 9780309052269.
- Marshall, W. *Nuclear Power Technology: Volume 2: Fuel Cycle*. New York, NY: Oxford University Press, 1984. ISBN: 9780198519584.

Course Title: Engineering Economics

Course Code: NE 2211

Credit Hour: 3.0

Course Description

This course is designed to emphasize the systematic costs and benefits assessment associated with proposed energy related or technical projects. The students will be exposed to the topics like economics and engineering, microeconomics and macroeconomics, theories of economics and also different economic models. Also concepts of the 'time value of money', discounted cash flow and economic decision making techniques will be discussed. Different methods of engineering economic analysis methods will be discussed.

Learning Outcomes

After completing this course:

- Explain the definition of economic and principles of economics.
- The students should be able to explain fluently describe the basics of nuclear medicine, including gamma camera and collimators.
- The students will understand the difference between micro and macroeconomics and will be able to explain different economic models.
- Students will be able to make economic analysis problems.
- Students will be skilled to choose the best alternatives by applying different economic analysis techniques like: Present or Future worth analysis, Benefit-Cost Ratio Analysis, Payback Period, Incremental Analysis and Rate of Return etc.
- The students will be able to present engineering economic problem and solution analysis.

Course Syllabus

Topic	Contents
Introduction to Engineering Economics	Basic definitions of economics, economics and engineering, principles of economics.
Making Economic	Introduction to different types of economic problems. Role of Engineering Economic Analysis in making economic decisions.

Decisions	Estimating cost and benefits.
Microeconomics	The theory of demand and supply and their elasticities, price determination, nature of an economic theory, applicability of economic theories to the problems of developing countries, indifference curve technique, marginal analysis, production, production function, types of productivity, rational region of production of an engineering firm, concepts of market and market structure, cost analysis and cost function, small scale production and large-scale production, optimization theory of distribution.
Macroeconomics	Savings, investment, employment, national income analysis, inflation, monetary policy, fiscal policy and trade policy with reference to Bangladesh.
Economics of planning and development	Economics of development and planning dimensions of development, relevance of theory, the employment problem, human resource development, planning and market, policy models, planning experience.
Time Value of Money	Interest and Equivalence in computing cash flow. Different interest formulas. Basic Aspects of Depreciation. Definitions for considering Inflation in Engineering Economy. Difference between Accounting and Engineering Economy.
Solving Economic Analysis Problems and Choosing the Best Alternative	Present Worth Analysis, Annual Cash Flow Analysis, Rate of Return Analysis, Incremental Analysis, Future Worth Analysis, Benefit-Cost Ratio Analysis and Calculation of Payback Period.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (3)	Introduction
	2 nd – 4 th (4)	Making Economic Decisions
	4 th – 6 th (4)	Microeconomics

	6 th -8 th (4)	Macroeconomics
	8 th – 11 th (6)	Economics of planning and development
	11 th – 12 th (3)	Time Value of Money
	13 th – 14 th (4)	Solving Economic Analysis Problems and Choosing the Best Alternative
	5 th	1 st In-course Examination and Presentation
	11 th	2 nd In-course Examination and Presentation

Recommended Readings

- Engineering Economic Analysis, Newnan D. G., Ted G. E. and Lavvelle J. P, International 10th Edition, Oxford University Press, NY, 2011.
- Contemporary Engineering Economics, Chan S. Park, Prentice-Hall, 2011, ISBN: 9780136118480.
- Engineering Economics, Riggs, 4th Edition, Tata McGraw-Hill Education, 2004. ISBN: 9780070586703.
- Fundamentals of Engineering Economics, Chan S. Park, 3rd Edition, Pearson Education, 2012. ISBN: 9780133072754.

THIRD YEAR FIRST SEMESTER:

Course Title: Electronics – II (Digital & Microprocessor)

Course Code:NE-3101

Credit: 3.0

Course description

This course is designed to facilitate the students to attain a thorough idea about the principle, operation and applications of various digital devices and microprocessor. The course mostly focuses on the theory and operation of the basic building blocks of digital electronics with emphasis on digital logics, combinational logics, sequential logics, digital numbers and arithmetic. The course also covers the topics of micro program Control, FPGA and HDLA. The students are required to have basic knowledge of analog electronics in order to complete this course effectively.

Learning outcomes

After completing this course the students are expected to be able to

- Perform basic arithmetic calculations in binary, decimal and hexadecimal.

- Evaluate logic circuit outputs, describe the operation of logic gates, and construct truth tables for logic gates.
- Perform combinational logic optimization using Boolean algebra and K-map.
- Understand about TTL, CMOS, ECL, RTL, NMOS, CMOS technology
- Solve problem using Verilog.
- Understand basic operation, design and applications of different types of flip-flops and counters; internal structure and operation of 8086 microprocessor
- Solve practical problems by designing their own counter and flip-flop circuits.
- Design half adder, full adder, ripple carry adder, BCD adder circuits.
- Illustrate the operation of encoders, decoders, multiplexers, shift registers, and wave generating circuits.
- Build various circuits based upon a desired outcome.
- Apply logic design circuits with Programmable Logic Devices
- Synthesize a circuit in a field programmable logic array (FPGA) using a logic compiler software on a personal computer.

Course syllabus

Topic	Contents
Number System	Decimal, binary, octal, hexadecimal, BCD number system and conversion, binary weighted codes, signed numbers, 1s and 2s complement codes, Binary arithmetic
Boolean Algebra	Binary logic functions, Boolean laws, truth tables, associative and distributive properties, DeMorgans theorems, realization of switching functions using logic gates.
Logic Gates	AND, OR, NAND, NOR, X-OR, X-NOR, Circuit Design.
Combinational logic operation	Parity generator; Laws of Boolean algebra; De-Morgan's theorem; Sum of product; Product of sum; k-maps, Multiplexer; demultiplexer; decoder; encoder; half-adder; full-adder; half-subtractor, full-subtractor, adder-subtractor.
Logic circuits	Flip-flops, registers & counters: R-S, D-type, Edge-triggered, J-K and J-K master slave flip-flops; serial and parallel shift registers; Synchronous and asynchronous counters; Up & down counters; Ripple counter. Mod-3 and Mod-5 counters, decade counters. Encoder, Decoder, Mux, Demux
Logic Families	DTL, TTL, CMOS, ECL, Tristate.
Memory Devices	ROM, RAM, Static, Dynamic, Memory Operation.
Arithmetic Circuits	Adder, Carry, Look Ahead, ALU.
Converter circuits	Analog to digital converter (ADC), Digital to Analog Converter (DAC).
PAL	Micro program Control, FPGA, HDLA.
Microprocessor	Introduction to microprocessors. Intel 8086 microprocessor:

Topic	Contents
	Architecture, addressing modes, instruction sets. Advanced microprocessors.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & simulation

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Number System
	2 nd (2)	Boolean Algebra
	3 rd – 4 th (4)	Logic Gates
	5 th (2)	Combinational logic operation
	6 th -7 th (4)	Logic circuits
	8 th (2)	Logic Families
	9 th (2)	Memory Devices
	10 th (2)	Arithmetic Circuits
	11 th (2)	Converter circuits
	12 th (2)	PAL
	13 th – 14 th (4)	Microprocessor
	7 th	1 st Incourse Examination
	13 th	2 nd Incourse Examination

Recommended readings:

- Digital Systems, Ronald J. Tossi, Neal S. Widmer, and Gregory L. Moss, 9th Edition, Pearson Education, Prentice Hall Inc.
- Digital Design, M. Morris Mano, Peter Spasov, 3, illustrated edition, Prentice Hall, 2002, ISBN: 9780131217881.
- An Introduction to Theory and Practice, Gothman , W. H.: Digital Electronics.
- Microprocessor & Microprocessor Based System Design by Dr. M. Rafiquzzaman.
- Microprocessor Architecture, Programming & Applications by R.S. Gaonker
- Robert L. Boylestad& Louis Nashelsky, Electronic Devices & Circuit Theory.
- William Kleitz, Digital Electronics, Prentice Hall International Inc.

Course Title: Electronics-II (Digital + Microprocessor) Laboratory**Course Code: NE-3102****Credit: 1.5****Course Description**

This course is designed to help the students to get a practical experience about the principle, operation and applications of various digital devices and microprocessors. The course mostly focuses operation of the basic building blocks of digital electronics with emphasis on digital logics, combinational logics, sequential logics, digital numbers and arithmetic. This course also provides the students with the practical knowledge of flip flops and their applications.

Learning Outcomes

On completion of the course, students are able to:

- Understand Combinational and logical digital circuits and their differences.
- To learn working principle of basic Digital electronics circuits for data processing application
- To understand the basic architecture of 8-bit microprocessors.
- Able to write programs on 8085 microprocessor based systems.
- Identify the addressing modes of an instruction.
- Develop programming skills in assembly language.

List of Experiments:

R1	Construction of basic gates [AND, OR and NOT] using discrete components [Resistor, Diode, Transistor etc.] & the verification of the truth table of the constructed gates.
R2	Implementation of a 4-bit parallel adder using 7483 IC.
R3	To study and verify NAND as a Universal Gate.
R4	Design an EX-OR gate using NAND gates.
R5	Circuit realization of logic expression using logic gates.
R6	Design (a) Half adder, Full adder and (b) Half subtract or, Full subtract or circuits using logic gates (AND, OR, XOR, etc.) and testing the circuits.
R7	Truth table verification of different FFs [S-R, J-K, D, T] and converting J-K FFs into D and T FFs.
R8	Design a 4-bit shift register using D flip-flop and verify its operation.
R9	Design a 3-bit ring counter and verify its operation.
R10	Design a frequency divider circuit using 3-bit asynchronous counter
R11	16-bit addition using 8086 microprocessor
R12	Conversion of BCD number to decimal in 8086 microprocessor.

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment Type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course Schedule

Class/week	Date: Week	Experiment
1	1 st	R1
	2 nd	R2
	3 rd	R3
	4 th	R4
	5 th	R5
	6 th	R6
	7 th	R7
	8 th	R8
	9 th	R9
	10 th	R10
	11 th	R11
	12 th	R12
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Digital Systems, Ronald J. Tossi, Neal S. Widmer, and Gregory L. Moss, 9th Edition, Pearson Education, Prentice Hall Inc.
- Digital Design, M. Morris Mano, Peter Spasov, 3, illustrated edition, Prentice Hall, 2002, ISBN: 9780131217881.
- An Introduction to Theory and Practice, Gothman , W. H.: Digital Electronics.
- Microprocessor & Microprocessor Based System Design by Dr. M. Rafiquzzaman.
- Microprocessor Architecture, Programming & Applications by R.S. Gaonker
- Robert L. Boylestad& Louis Nashelsky, Electronic Devices & Circuit Theory.
- William Kleitz, Digital Electronics, Prentice Hall International Inc

Course Title: Materials Science for Nuclear Applications**Course Code: NE-3103****Credit Hour: 3.0****Course description**

At the beginning of the course the students will get a fundamental knowledge of materials science and engineering which will help them to comprehend the remaining topics. The course mostly focuses on the phase diagrams and phase transformation in detail. Special attentions are given on applications and processing of metal alloys. The course also covers the topics radiation effects in materials and corrosion. After completing above topics the students will study about nuclear reactor fuel, moderator, control and structural materials comprehensively.

Learning outcomes

After completing this course the students should be able to

- Understand the classification and properties of materials, crystal structure and crystal defects, mechanical properties, different tests for ductility, hardness measurement, and basics of fracture mechanics, fatigue and creep.
- Describe the condition of solid solubility, phase and phase diagram, types of phase diagram, iron-iron carbide phase diagram, development of microstructure in isomorphous and eutectic alloys and also in iron–carbon alloys.
- Explain the kinetics of phase transformations, isothermal transformation diagrams, continuous cooling transformation diagrams, how transformation occurs in iron–carbon alloys and mechanical behavior of pearlite, bainite, spheroidite, martensite and tempered martensite.
- Illustrate the properties of different ferrous and nonferrous alloys, different metal formation techniques, annealing processes, heat treatment of steels and precipitation hardening.
- Depict the different types of corrosion, their causes and mitigations control of reactor water chemistry parameters, and corrosion issues in nuclear engineering.
- Explain the radiation damage, ion irradiation effects, and radiation effects in reactor materials.
- Describe the properties of reactor fuel, coolant, moderator and control material, structural materials of different reactor components, and their ageing mechanism and mitigation techniques.
- Calculate the yield strength, ductility, stress intensity factor, number of phases in an alloy at a particular temperature and composition, phase composition, mass/volume fraction of liquid/solid phase, corrosion penetration rate (CPR), displacement per atom (DPA) etc.

Course syllabus

Topic	Contents
Fundamentals	Introduction to material science and engineering, atomic and ionic arrangement, crystal defects, mechanical properties: basics and tensile, hardness, and impact testing; fracture mechanics, fatigue, and creep behavior.
Phase diagrams	phases, microstructure, Gibbs phase rule, solubility limit, phase equilibrium, interpretation of phase diagrams, unary phase diagrams, binary isomorphous systems, development of microstructure in isomorphous alloys, mechanical properties of isomorphous alloys, binary eutectic systems, development of microstructure in eutectic alloys, equilibrium diagrams having intermediate phases or compounds, eutectoid and peritectic reactions, the iron–iron carbide (Fe–Fe ₃ C) phase diagram, development of microstructure in iron–carbon alloys, the influence of other alloying elements.
Phase transformations	Basic concepts, the kinetics of phase transformations, metastable versus equilibrium states, isothermal transformation diagrams, continuous cooling transformation diagrams, mechanical behavior of iron–carbon alloys tempered martensite.
Applications and processing of metal alloys	Introduction, ferrous alloys, nonferrous alloys, annealing processes, heat treatment of steels, precipitation hardening.
Corrosion	Introduction, electrochemical considerations, corrosion rates, prediction of corrosion rates, forms of corrosion, corrosion environments, corrosion prevention, oxidation, reactor water chemistry, and corrosion issues in nuclear engineering.
Radiation effects in materials	Kinematics and interaction potentials, radiation damage, ion irradiation effects, radiation effects in reactor materials.
Reactor materials	Properties of nuclear reactor materials (fuel, coolant, moderator and control material), structural materials of different components, their ageing mechanism and mitigation.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5

Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st - 2 nd (4)	Fundamentals
	3 rd - 4 th (4)	Phase diagrams
	5 th - 6 th (4)	Phase transformations
	7 th - 8 th (3)	Applications and processing of metal alloys
	8 th - 9 th (3)	Corrosion
	10 th - 11 th (3)	Radiation effects in materials
	11 th - 14 th (7)	Reactor materials
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- W.D. Callister, Jr., Materials Science and Engineering – An Introduction, 8th Edition, John Wiley & Sons, Inc. 2007, ISBN: 0-471-73696-1
- Essentials of Materials Science and Engineering, Second Edition, Donald R. Askeland, Pradeep P. Fulay, D. K. Bhattacharya, ISBN-13: 978-0-495-43850-2
- Nuclear Reactor Engineering, Glasstone and Sesonske, Third ed.
- Applied Reactor Technology, Henryk Anglart, 2011.
- S. Was, Fundamentals of Radiation Materials Science: Metals and Alloys Springer, 2007, ISBN: Gary 978-3-540-49471-3.
- Michael F. Ashby and David R. H. Jones, Engineering Materials 1: An Introduction to Properties, Applications and Design, 3rd Edition, Elsevier Butterworth Heinemann, 2005, ISBN: 0-7506-63804
- T. Rick Irvin, Naturally Occurring Radioactive Materials: Principles and Practices, Illustrated Edition, CRC Press, 1996. ISBN: 9781574440096.
- Ioan Ursu, Physics and Technology of Nuclear Materials, Illustrated Edition, Pergamon Press, 1985.

Course Title: Thermal Hydraulics and Reactor Safety Lab

Course code: NE-3104

Credit: 1.5

Course description:

Research in thermal hydraulics and reactor safety encompasses studies of two-phase flow, heat transfer, phase change, coolant dynamics, liquid metal flow, and various phenomena related to reactor safety. The thermal-hydraulic and reactor safety laboratory consists of

experimental loops and computer codes for studying nuclear thermal-hydraulics and two-phase flow.

Learning Outcomes:

Students have the ability of theoretical calculations and/or qualitative explanation on the following items: (1) Generation of heat in nuclear reactor, (2) Heat conduction in fuel elements of nuclear reactors, (3) Single-phase flow cooling of nuclear reactors, (4) Phase changes of reactor coolants, (5) Boiling two-phase flow cooling of nuclear reactors, (6) Thermal-hydraulic phenomena related to nuclear reactor safety, (7) Energy conversion from heat to power in nuclear reactor

List of Experiments:

1. Experimental studies to characterize a variety of two-phase flow patterns
2. Experimental studies of steam turbine miniature power plant using Rankine cycle
3. Thermal power plant visit
4. Nuclear accident analysis using PC tran

Course Components (Learning Activities): Experiments, Report writing, Viva-voce, Quiz, power plant visit, Demonstration, Examinations.

Assessment Type:

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course Schedule:

One class 3-hour duration per week. Total number of classes will be 14 weeks in one semester.

Recommended Books:

- YunusA.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
- Holman.J.P, Heat Transfer, Tata McGraw Hill, 2002.
- Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
- Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
- Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
- Christopher Earls Brennen, Thermo-Hydraulics of Nuclear Reactors,Dankat Publishing Company.
- James J. Duderstadt, Louis J. Hamilton, Nuclear Reactor Analysis, Wiley Publisher.

Course Title: Thermal Hydraulics and Reactor Safety

Course Code: NE-3105

Credit: 3.0

Course description

The course is meant to cover more than thermal hydraulic design and analysis of the core of a nuclear reactor. Thus, in several parts and examples, other components of the nuclear power plant, such as the pressurizer, the containment and the entire primary coolant system are addressed. In this respect the course reflects the importance of such considerations in thermal engineering of a modern nuclear power plant. The basic ideas of both fluid flow and heat transfer as applicable to nuclear reactors are discussed this course.

Specific Objectives

The objective of this course is to describe the basic concepts and engineering methods used in the formulation of the analyses of thermal processes taken place in a nuclear system during normal operation and under postulated accident conditions

Learning outcomes

After completing this course the students should be able to

- An understanding of the principles and concepts of thermal-hydraulic design of nuclear reactors
- Knowledge of general design principles, with a focus on the main parameters, design limits, and thermal-hydraulic margins by which the thermal-hydraulic design is characterized.
- An understanding of the design concepts and key features of the primary and secondary heat transport systems
- Knowledge of the details of different heat transfer and fluid flow and the heat transfer methodology used in the thermal hydraulics of the reactor heat transport system.
- Apply fluid transport equations in different types of flow
- Understand about the basics of thermal hydraulic codes
- Knowledge of the safety guides and requirements related to the design and deterministic safety analysis of nuclear power plants

Course syllabus

Fundamentals of heat transfer mechanisms and fluid mechanics in fluids and analogies. Energy and core flow distribution, Reactor heat generation and transfer; radial and axial temperature distributions in fuel elements, Applications of single-phase, two-phase flow and convective boiling to reactor coolant channel analysis, core thermal design and safety analysis, Two-phase flow patterns, Critical heat flux, DNBR, AOOs, Void coefficient, Radiative heat transfer, Thermal hydraulic safety limits and conditions, Current research topics of the nuclear thermal-hydraulics concerned with safe and effective heat removal from the reactor core for power production. Analysis of operational and accident transient sequences, nuclear and thermal-hydraulic transient,

and engineering aspects of nuclear reactor operational safety, IAEA safety standards requirements.

Course components (Learning activities)

Lecture, Discussion, Assignment, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 th (4)	Fundamentals of conduction and convection heat transfers and fluid flow mechanisms
	3 th –4 th week (4)	Heat generation calculation and heat transfer analysis from fuel elements through conduction mechanism in radially and axially and problem solving
	5 th –7 th week (6)	Convection heat transport analysis (single-phase) for laminar and turbulent flows, Hydraulic diameter, Dimensionless parameters for heat and mass transfer, Boundary layer thickness, Problem solving based on convective heat transfer for LWRs, HWRs, GCRs
	8 th -10 th (6)	Fundamentals of two-phase boiling heat transfer analysis, Sub-channel analysis, Accident situations, thermal-hydraulic design limits and conditions, CHF, AOOs, DNBR
	11-12 th (4)	Empirical correlations for boiling heat transfer, Void fraction calculations, Homogeneous Equilibrium and Drift Flux Models,
	13 th (2)	Introduction to thermal-hydraulic codes and Applications to thermal-hydraulic codes

	14 th (2)	IAEA safety standards, Safety objectives, Safety functions and safety principles, Reactor operational safety
	7 th	1 st Incourse Examination
	14 th	2 nd Incourse Examination

Recommended Readings

- Neil E. Todreas, Mujid S. Kazimi, Nuclear systems I: Elements of Thermal Hydraulic Design.
- Hajime. Akimoto, Yoshinari. Anoda, Kazuyuki. Takase, Hiroyuki. Yoshida, Hidesada. Tamai, Nuclear Thermal Hydraulics, Springer, 2009.
- Henryk Anglart, Thermal-Hydraulics in Nuclear Systems.
- Christopher Earls Brennen, Thermo-Hydraulics of Nuclear Reactors, Danks Publishing Company.
- James J. Duderstadt, Louis J. Hamilton, Nuclear Reactor Analysis, Wiley Publisher.
- “Fundamentals of Heat and Mass Transfer”, Incropera, DeWitt, Bergman, Lavine, John Wiley and Sons, Sixth Edition, 2007.
- “Deterministic Safety Analysis”, Regulatory Document REGDOC-2.4.1, Canadian Nuclear Safety Commission (CNSC), 2014.
- “Design of Reactor Facilities: Nuclear Power Plants”, Regulatory Document REGDOC2.5.2, Canadian Nuclear Safety Commission (CNSC), 2014.
- “Deterministic Safety Analysis For Nuclear Power Plants”, IAEA Safety Standards Series No. SSG-2, 2009.

Course No.: NE 3107

Course Title: Complex Variables and Laplace & Fourier Transformations

Credit Hour: 3.0

Course Description

This course is a study of the basic tools in the use of complex variables, Laplace transformation as well as Fourier transformations along with Fourier integrals to solve practical problems in Applied Mathematics and Physics. It continues the use of integral transform methods to solve ordinary and partial differential equations. The following topics will be examined: the complex plane, analytic functions, integration and Cauchy's Theorem, sequences and series, residue calculus, Fourier and Laplace transforms, and applications.

This course is aimed to provide an introduction to the theories for functions of a complex variable. It begins with the exploration of the algebraic, geometric and topological structures

of the complex number field. The concepts of analyticity, Cauchy-Riemann relations and harmonic functions are then introduced. The notion of the Riemann sheet is presented to help student visualize multi-valued complex functions. Complex integration and complex power series are presented. We then discuss the classification of isolated singularities and examine the theory and illustrate the applications of the calculus of residues in the evaluation of integrals. Students will be equipped with the understanding of the fundamental concepts of complex variable theory. In particular, students will acquire the skill of contour integration to evaluate complicated real integrals via residue calculus. The prerequisites are some knowledge of calculus (up to line integrals and Green's theorem), and some basic familiarity with differential equations would be useful.

Learning Outcomes

In this course students will learn the algebra and geometry of complex numbers, mappings in the complex plane, the theory of multi-valued functions, the calculus of functions of single complex variable and the Laplace transform. In particular, students after completing this course are expected to be able to

- perform critical mathematical operations (arithmetic's, powers, roots) with complex numbers in Cartesian and polar forms;
- Describe domains and compute limits in the complex plane.
- determine continuity/differentiability/analyticity of a function
- work with multi-valued functions (logarithmic, complex power) and determine branches of these functions logically;
- Use line and contour integration to evaluate integrals.
- calculate Taylor or Laurent series for functions
- • compute the numerical value of the residue of a function and use the residue theory to evaluate a contour integral or an integral over the real line;
- find the Laplace Transform and the Inverse Laplace Transform of a function;
- Compute Fourier and Laplace transforms.

Course Syllabus:

Topic	Contents
Functions of a Complex Variables	Complex numbers, Powers and roots, Sets in the complex plane, Functions of a complex variable, Cauchy-Riemann equations, Exponential and logarithmic functions, Trigonometric and hyperbolic functions, Inverse trigonometric and hyperbolic functions.
Integration in the Complex Plane	Contour integrals, Cauchy-Goursat theorem, Independence of the path, Cauchy's integral formulas
Series and Residues	Sequences and series, Taylor series, Laurent series, Zeros and poles, Residues and residue theorem, Evaluation of real integrals.
Conformal Mappings	Complex functions as mappings, conformal mappings, Linear fractional transformation.
Laplace Transformation	Definition of Laplace transformation, Notation, Laplace transformations of some elementary functions, The inverse Laplace transformation and transforms of derivatives, Translation theorems,

	Additional operational properties, The Dirac Delta function, Applications to differential equations
Fourier Transformation	Fourier series, Fourier cosine and sine series, Complex Fourier series, Fourier integral, Fourier transforms.

Course Components

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & simulation

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st -2 nd (4)	Functions of a Complex Variables
	3 rd -5 th (6)	Integration in the Complex Plane
	6 th -7 th (4)	Series and Residues
	8 th -9 th (4)	Conformal Mappings
	9 th -11 th (6)	Laplace Transformation
	12 th -14 th (4)	Fourier Transformation

Recommended Readings

- Dennis G. Zill & Warren S. Wright, Advanced Engineering Mathematics, Fifth Edition, 2014.
- Saff, Edward B., and Arthur David Snider. Fundamentals of Complex Analysis with Applications to Engineering, Science, and Mathematics. 3rd ed. Upper Saddle River, NJ: Prentice Hall, 2002.
- J.E. Marsden, M.J. Hoffman, Basic complex analysis, 3rd ed. Freeman and Company, ISBN: 0-7167-2877X.
- Ahlfors, Lars V. Complex Analysis: An Introduction to the Theory of Analytic Functions of One Complex Variable. 3rd ed. New York, NY: McGraw-Hill, 1979. ISBN: 9780070006577.

Course Title: Numerical Method in Reactor Engineering Analysis**Course Code: NE 3109****Credit: 3.0****Course Description**

This course is an introduction to the numerical methods for reactor engineering analysis. The primary objective of the course is to develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer. Here the dynamical programming language MATLAB is introduced to illustrate the numerical solutions for real life problems. More details are given in the course goals below.

- To give knowledge on some basic numerical methods.
- To know how to interpret the numerical solutions of IVPs and BVPs.
- To know about the application numerical methods to solve various real life problems.
- To know how to fit data using various existing techniques.

Learning Outcomes

Upon successful completion of this course, the student will be able to

- Effectively write mathematical solutions and their interpretation in a clear and concise manner. This will be assessed through class quizzes and tests and a final exam.
- Locate and use information to numerically solve problems. This will be assessed through homework, class quizzes and tests, and a final exam.
- Work effectively with others to complete homework and class assignments. This will be assessed through graded assignments and class discussions.
- Demonstrate ability to think critically by analyzing a practical problem and understanding the mathematical basis of the problem. . This will be assessed through class assignments, tests and a final exam.
- Demonstrate ability to think critically by developing and implementing algorithms to for solving application problems. . This will be assessed through class assignments, tests and a final exam.
- Demonstrate the ability to study the solution of a differential equation and develop a practical interpretation of the numerical results. This will be assessed through class quizzes and tests and a final exam.

Course Syllabus

Topics	Contents
Preliminaries of Computing	Basic concepts: round-off errors, floating point arithmetic, Convergence.
Numerical solution of Nonlinear Equations	Bisection method, fixed-point iteration, Newton's method, Error analysis for Iterative Methods, Computing roots of polynomials.
Interpolation and Polynomial Approximation	Lagrange Polynomial, Divided Differences
Numerical integration and differentiation	Trapezoidal rule, etc., Gaussian quadrature and Euler-Maclaurin formula.
IVP problems for ODE	Euler's, Taylor, Runge-Kutta, and multistep methods, Stability
Numerical linear algebra	Direct methods, Iterative methods
Approximation theory	Power method, Householder's method
Approximating Eigenvalues	Power method, Householder's method
BVP for ODE	Finite difference methods, Shooting methods
Introduction to MATLAB programming	

Course Components

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & simulation

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (1)	Basic concepts: round-off errors, floating point arithmetic, Convergence.
	2 nd -3 rd (2)	Bisection method, fixed-point iteration, Newton's method, Error analysis for Iterative Methods,

Class/week	Date: Week (Classes)	Topic
		Computing roots of polynomials.
	4 th -5 th (2)	Lagrange Polynomial, Divided Differences
	6 th -7 th (2)	Trapezoidal rule, etc., Gaussian quadrature and Euler-Maclaurin formula.
	8 th -9 th (2)	Euler's, Taylor, Runge-Kutta, and multistep methods, Stability
	10 th (1)	Direct methods, Iterative methods
	11 th (1)	Power method, Householder's method
	12 th (1)	Power method, Householder's method
	13 th (1)	Finite difference methods, Shooting methods
	14 th (1)	Introduction to MATLAB programming

Recommended Readings

- Richard L. Burden and J. Douglas Faires, Numerical Analysis, 8th Edition. Student Edition: ISBN-10: 0-534-39200-8
- J. Stoer and R. Bulirsch, Introduction to Numerical Analysis, Springer-Verlag, ISBN 0-387- 90420-4
- L.N. Trefethen and D. Bau, Numerical Linear Algebra, Society of Industrial and Applied Mathematics [3] C.T. Kelley, Iterative methods for linear and nonlinear equations, Society of Industrial and Applied Mathematics

Course Title: Engineering Mechanics

Course Code: NE-3111

Credit Hour: 3.0

Course description

Engineering mechanics is understood by many to be the application of mechanics to solve problems. For engineers, one must first examine the fundamentals of engineering mechanics, and then see how these fundamentals work together to solve engineering problems. Mechanics has two parts- statics and dynamics. Both consist of various topics. Some of the topics will be new to the students especially in statics. On the contrary, the dynamic parts are more or less introduced to the students in their physics course.

Learning outcomes

After completing this course the students should be able to achieve-

- An ability to identify, to formulate, and solve engineering problems. This includes:
 - An ability to apply knowledge of basic mathematics, science and engineering
 - An ability to use advanced mathematical and computational techniques to analyze, model, and design physical systems, components under steady state and transient conditions.
 - An ability to design a system, component or process to meet desired needs.
 - An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
- An ability to design and conduct experiments, as well as to analyze and interpret data.

Course syllabus

Topic	Contents
Introduction	Mechanics and nuclear Engineering.
Statics	Force: Resultant force and methods of resultant force, composition of forces, resolution of force and method of resolution for the resultant force
	Moments and couples: Introduction, Law of moments, position of resultant force using moments, Levers & types of levers, Parallel forces-analytical method for resultant parallel force, couples and related problems.
	Equilibrium of Forces: Conditions of equilibrium, types of equilibrium, principles of equilibrium, Lami's principle, graphical methods for coplanar force equilibrium.
	Centre of gravity: Centroid & methods for Centre of gravity.
	Moment of inertia: Routh's Law, Finding moments of inertia of different types of sections.
	Friction: Static & dynamic friction, laws of friction, equilibrium of body on different type of rough planes-horizontal plane, inclined plane & force acting at angles; applications of friction-ladder friction.
	Machine: Ideal machine, efficiency, mechanical advantage, reversibility of machine, self-locking machine, law of machine.
	Support reactions: Analytical method for the reaction of a beam, Simply supported beams, overhanging beams, hinged beams, beams subjected to moment.
	Truss analysis: simply supported ends, one end hinged and other on rollers, both end fixed, method of Joints & method of Sections.

Topic	Contents
Dynamics	Linear motion: motion under acceleration and gravity, graphical representation of linear motion.
	Motion under variable acceleration: Calculation by integration, differentiation & table formation.
	Relative velocity: Rain & man, two bodies moving along inclined directions.
	Projectiles: Equation of projectiles, motion of projectiles, time, range and maximum height, projection on an inclined plane.
	Motion of rotation: rotational motion under constant angular acceleration, linear motion of a rotating body.
	Simple Harmonic Motion: General conditions, velocity and acceleration combined with finding maximum value.
	Laws of motion: Newton's laws of motion, motion of a lift, D'Alembert's law, motion on inclined plane.
	Motion of connected bodies: Two bodies connected by a string and different cases-body lying on horizontal and inclined plane, plane with friction
	Collision: law of conservation of momentum, direct collision of two bodies, loss of kinetic energy during collision.
	Motion along circular path : Centripetal and centrifugal force, superelevation, equilibrium speed for superelevation
	Work, power and energy: Transformation of energy, law of conservation of energy.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial & Problem Solving Class.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course schedule:

Class/week	Date: Week (Classes)	Topic
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2	1 st – 5 th (10)	Introduction, Force, Moments and couples, Equilibrium of Forces
	6 th – 7 th (4)	Centre of gravity, Moment of Inertia
	8 th – 9 th (4)	Friction, Machine, Support reactions, Truss analysis.
	10 th -11 th (4)	Linear motion, Motion under variable acceleration, Relative velocity, Projectiles.
	12 th (2)	Motion of rotation, Simple Harmonic Motion, Motion along circular path
	13 th (2)	Work, power and energy , Collision
	14 th (2)	Laws of motion, Motion of connected bodies
	5 th	1 st In course Examination
	11 th	2 nd In course Examination

Recommended Readings

- Engineering mechanics, R.C. Hibbeler
- A textbook of engineering Mechanics, R.S. Khurmi
- Engineering Mechanics, Bedford & Flower.
- A Textbook of Engineering Mechanics, R.K. Bansal
- Engineering Mechanics, J.L. Meriam and L. Kraige

Course Title: Foreign Language (Russian)

Course Code: NE-3113

Credit Hour: 2.0

Course description

This course is designed to facilitate the students to acquire a basic knowledge of Russian Language. The course mostly focuses on reading, writing& listening skills. Special attentions are given in grammar and speaking skills. The course also covers description of various days, months, seasons, WH questions, numerals etc.

Learning outcomes

After completing this course the students should be able to

- Understand Russian alphabets
- Distinguish between genders of noun
- Convert singular word to plural word
- Use possessive pronouns and objective pronouns
- Use tense precisely (the present & past tenses)
- Conjugate verbs
- Distinguish between animated and inanimate nouns
- Write numerals in Russian
- Talk about location
- Describe month, season & days
- Write about him/herself

Course syllabus

Topics
Russian alphabets
Gender of nouns
Numerals
Singular and Plural of nouns
Use of “What” & “Who”
Conjugation of verb
Possessive pronouns
Use of ‘Have/Has’
Describing place
Use of “Where” & “When”
Describing season, month, and days
Writing paragraph

Course components (Learning activities)

Lecture, Reading, Writing, Interactive session, Question-Answer session.

Assessment type

Assessment type	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (4)	Russian Alphabets
	3 rd (2)	Gender of nouns

	4 th -5 th (4)	Animated and inanimate, Conjugation of verb
	6 th (2)	Numerals and Singular-plural
	7 th (2)	Possessive pronouns
	8 th (2)	Some special conjugations and the use of “have/has”
	9 th (2)	Use of where and when
	10 th (2)	Describing season, month, and days
	11 th (2)	Incourse exam

Recommended Readings

- Chernyshov, S.I, “Let’s go! Russian for adults. A course for beginners”. 7th ed.- St. Petersburg: Zlatoust 2009. - 280 p.

THIRD YEAR SECOND SEMESTER:

Course Title: Nuclear Electronics, Instrumentation and Measurement

Course Code: NE-3201

Credit Hour: 3.0

Course description

This course is designed to facilitate the students to acquire a thorough idea of instrumentation system for measuring different physical parameters. The course mostly focuses on basic measurement techniques of displacement, area, flow, pressure, temperature, vibration and their applications in nuclear power plant. Special attentions are given in the reactor instrumentation and plant radiation monitoring systems. The course also covers the topic plant control. The students should have a basic knowledge of analog and digital electronics in order to complete this course effectively.

Learning outcomes

After completing this course the students should be able to

- Analyze different experimental data and error.
- Demonstrate different types of measurement techniques for displacement, area, flow, pressure.
- Explain properties of various thermal sensors and their operating principles.
- Describe the instrumentation and measurement techniques for nuclear power plant parameters.
- Comprehend the control principles and methods of control for different plant parameters.

- Demonstrate plant radiation monitoring system for normal operation and accidental situation.

Course syllabus

Topic	Contents
Data Analysis	Causes and Types of Experimental Errors, Uncertainty Analysis and Propagation of Uncertainty, Evaluation of Uncertainties for Complicated Data Reduction, Statistical Analysis of Experimental Data, Probability Distributions, The Gaussian or Normal Error Distribution, Standard Deviation of the Mean
Displacement and Area	Introduction, Optical Methods, Pneumatic Displacement Gage, Area Measurements, Planimeter, Graphical and Numerical Methods for Area Measurement, Surface Areas
Pressure Measurement	Introduction, Mechanical Pressure-Measurement Devices, Dead-Weight Tester, Bourdon-Tube Pressure Gage, Diaphragm and Bellows Gages, Low-Pressure Measurement, The McLeod Gage, Pirani Thermal-Conductivity Gage, The Knudsen Gage, The Ionization Gage
Flow Measurement	Positive-Displacement Methods, Flow-Obstruction Methods, The Sonic Nozzle, Flow Measurement by Drag Effects, Hot-Wire and Hot-Film Anemometers, The Laser Doppler Anemometer (LDA)
Temperature Measurement	The Ideal-Gas Thermometer, Temperature Measurement by Mechanical Effects, Electrical Effects and Radiation, Effect of Heat Transfer on Temperature Measurement, Thermocouple Compensation
Thermal- and Transport-Property Measurements	Thermal-Conductivity Measurements, Thermal Conductivity of Liquids and Gases, Measurement of Viscosity, Gas Diffusion, Calorimetry, Convection Heat-Transfer Measurements, Humidity Measurements, Heat-Flux Meters, pH Measurement
Reactor Instrumentation	Overview of reactor systems, Out core sensors: source, intermediate and power range neutron sensor, log count rate meter, period meter, startup rate meter, In core sensors: fission chamber, B-10 lined ion chamber, self powered neutron detector (SPND), travelling and moving sensor, thermocouple, RTD, TTFM, N-16 power monitoring system, Sensor performance and reliability test, Calibration, Process instrumentation, Signal conditioning, Control rod drives and

Topic	Contents
	indicating systems; Power supplies, Installation of instrumentation systems; Quality assurance and reliability
Plant Control	Reactor kinetics, Transfer function, Transfer function measurement systems, range of reactor control, reactor protection system, primary & secondary control desk, pressure, temperature, flow, water level control in NPP, reactor control loop, turbine follows reactor and reactor follows turbine principles.
Plant Radiation Monitoring	Function, continuous area monitoring system (CAM), fixed filter CAM and moving filter CAM, Process radiation monitoring instrumentation, Radiation Monitoring instrumentation for accident situation, HEPA filter, Charcoal filter, compensated ion chamber, personnel dosimeters.

Course components (Learning activities)

Lecture, Discussion, Assignment, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Data Analysis
	2 nd (2)	Displacement and Area
	3 rd (2)	Pressure Measurement
	4 th (2)	Flow Measurement
	5 th (2)	Temperature Measurement
	6 th – 7 th (4)	Thermal-and Transport- Property Measurements
	8 th – 10 th (6)	Reactor Instrumentation
	11 th -13 th (6)	Plant Control
	14 th (2)	Plant Radiation Monitoring

	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Experimental Methods for Engineers (Eighth Edition) by J. P. Holman. Mac Graw hill publications.
- Theory and Design for Mechanical Measurements (Fifth Edition) by Richard S. Figliola and Donald E. Beasley. John Wiley & Sons, Inc
- Doe fundamentals handbook: Instrumentation and Control, U.S. Department of Energy
- Nuclear Power Reactor Instrumentation Systems Handbook, Joseph M. Harrer and James G. Beckerley, Vol 1 & 2, 1973.

Course Title: Nuclear Electronics, Instrumentation and Measurement Laboratory

Course Code: NE-3202

Credit Hour: 1.5

Course Description

This course is designed to facilitate the students to acquire a thorough idea of instrumentation system for measuring different physical parameters. The course mostly focuses on basic measurement techniques of displacement, area, flow, pressure, temperature, vibration and their applications in nuclear power plant. Special attentions are given in the reactor instrumentation and plant radiation monitoring systems. The course also covers the topic plant control. The students should have a basic knowledge of analog and digital electronics in order to complete this course effectively.

Learning outcomes

The student will be able to perform experiments to determine various types of errors in measurements.

The students will be familiar with various measuring instruments used to detect electrical quantities.

Course Syllabus

Topic	Contents
Basic sensor handling	Thermistor, LM35 for temperature., DHT sensor handling.
Motor Control	DC motor control, Servo motor control, Steeper motor control.

Displacement Measurement	Alignment measurement, Motion sensing, PIR sensing.
Fluid Measurement	Water level measurement, Water flow measurement
Communication & Networking	Bluetooth communication with microcontroller, Laser communication over 1@m, Wi-Fi networking
Data acquisition & Recording	Sensor data recording with microcontroller, Wireless sensor handling with virtual data server.

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of Experimental Setup, Experiment, Discussion on Results

Assessment type

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course schedule

Class/week	Date: Week(Classes)	
1	1st to 12th	Experiment
	13 th	Lab Practice Class
	14 th	Final Examination

Recommended Readings

- Experimental Methods For Engineers(Eighth Edition)by J. P. Holman. Mac Graw hill publications.
- Theory and Design forMechanical Measurements (Fifth Edition) by Richard S. Figliola and Donald E. Beasley. John Wiley & Sons, Inc
- Doe fundamentals handbook: Instrumentation and Control, U.S. Department of Energy
- Nuclear Power Reactor Instrumentation Systems Handbook, Joseph M. Harrer and James G. Beckerley, Vol 1 & 2, 1973.

Course Title: Electrical Power Transmission and Distribution**Course Code: NE-3203****Credit Hour: 3.0****Course description**

This course is designed to make the students knowledgeable about the basics of Electrical power and its Transmission and Distribution. The course mostly focuses on Circuit Breakers, Load curve and Relays. The course also covers Power factor calculations and its improvement process and necessity. Electrical grid system and the protection scheme of different type's electrical instrument are also discussed in this course. The students should have a basic knowledge about high school physics, Basic mathematics, and calculus in order to complete this course effectively.

Learning outcomes

After completing this course the students should be able to

- Understand the Basics of nuclear power generation and its requirements.
- Explain Load curves in details.
- Differentiate between Load curves and Load duration curve and also among the different types of circuit breakers and Relays.
- Get idea about Power factor and the necessity of its improvement.
- Illustrate the Circuit breakers.
- Depict the Relays
- Be familiar with Trip Circuits and its protection.
- Calculate the different types of factor (demand, diversity, load capacity and plant factor), power factor and the total cost of used electricity and instrument that are used during power factor improvement.
- Apply their acquirement in the related research field.

Course syllabus

Topic	Contents
Introduction	Basics of nuclear power generation from NPPs, power requirements (stability, quality, and reliability), power transmission and distribution systems, emergency power supply system and power requirements in NPP, Circuit interruption and protection, Terminologies and general characteristics of relays and breakers. AC/DC converter.
Load curves	Demand factor, diversity factor, load duration curves, energy load curve, load factor, capacity factor and plant factor.
Power factor	Power factor, Power triangle, Disadvantage of low power

Topic	Contents
Improvement	factor, Causes of low power factor, Power factor improvement, Power factor improvement equipment, Calculation of power factor corrections, Importance of power factor improvement, Most economical power factor,
Circuit breakers	Control systems, arc extinction, and recovery voltage. Air, oil, air blast circuit breaker, vacuum, SF6 and high voltage DC circuit breakers, testing of circuit breakers
Relays	Over current, directional, differential, distance, sequence, pilot-wire and carrier-current protection. Busbar arrangement, grounding.
Unit protection	Generator, motor, transformer, bus and line protection. Protective schemes, instrument transformers. Basic static and microprocessor based relays.
Trip Circuits	Unit protection schemes: Generator, transformer, motor, bus bar, transmission and distribution lines, Instrument transformers: CT and PT
Grid system	Typical layout of a substation, High tension switch gear, Low tension switch gear, Transmission cables, Transmission tower, Corona, High voltage measurements and testing. Over-voltage phenomenon and insulation coordination. Lightning and switching surges, basic insulation level, surge diverters and arresters.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (4)	Overview of Nuclear Power
	3 rd - 4 th (4)	Load curves
	5 th -6 th (4)	Power factor Improvement
	7 th -8 th (4)	Circuit breakers
	9 th (2)	Relays
	10 th (2)	Unit protection

	11 th -12 th (4)	Trip Circuits
	13 th -14 th (4)	Grid system

Recommended Readings

- Principles of power system, V.K. Mehta, Rohit Mehta
- Switchgear and Protection, Sunil S. Rao
- High Voltage switch gear Analysis and Design, Chunikhin M. Zhavoronkov, 1st edition, 1989, Mir publishers Moscow
- Switch gear and Finite Automata Theory, Kohavi, 2nd edition, 2005, Tata McGraw Hill

Course Title: Virtual Instrumentation Modeling and Simulation/MATLAB and Lab VIEW

Course Code: NE 3204

Credit Hour: 1.5

Course description

This lab course is designed to help the students to get a knowledge on virtual instrumentation, modeling and simulation using MATLAB/ LabVIEW software.

List of Experiments:

R1	Calculation of binding energy of isotopes using MATLAB.
R2	To evaluate elements on the basis of atomic mass number to determine the more suitable scatterer.
R3	Graphical representation of activity of daughter nuclei with respect to time and activity of parent nuclei.
R4	Plotting the terms of Semi-Empirical Mass formula using subplot.
R5	Simulation and study of (i) Range- energy curve for beta particles (ii) Bremsstrahlung fraction-energy curve for beta particles
R6	Study of heat generation distribution in a homogenous cylindrical core.

Course components (Learning activities)

Lecture on Theoretical Background, Demonstration of operating the software, Experiment, Discussion on Results.

Assessment type

Parameter	Percentage (%)
○ Attendance	10
○ Continuous Assessment	30
○ Examination	20
○ Viva-voce	20
○ Simulator practice and viva-voce	20

Recommended Readings

- MATLAB: A Practical Introduction to Programming and Problem Solving, 5e, Stormy Attaway, Butterworth-Heinemann, 2019.
- MATLAB Programmin, Daniel Okoh, Createspace, 2018.
- Introduction to MATLAB for Engineers and Scientists: Solutions for Numerical Computation and Modeling, Sandeep Nagar, Apress, 2017.
- Lamarsh, John R., and Anthony J. Baratta. Introduction to Nuclear Engineering. 3rd ed. Englewood Cliffs, NJ: Prentice Hall, 2001. ISBN: 9780201824988.
- T. Jevremovic, Nuclear Principles in Engineering, 2nd Edition, Springer 2009, ISBN: 978-0-387-85607-0

Course schedule

Class/week	Date: Week	Experiment
1	1 st	Introduction to MATLAB.
	2 nd	Mathematical functions, Basic plotting, Matrix Generation.
	3 rd	Array Operations and Linear Equations
	4 th	Introduction to programming in MATLAB.
	5 th	Control Flow and Operators.
	6 th	Quiz- 1
	7 th	R1
	8 th	R2
	9 th	R3
	10 th	R4
	11 th	R5
	12 th	R6
	13 th	Presentation and Viva-Voce (As a part

		of continuous Assessment)
	14 th	VVER-1200 Simulator Workshop at AEC (Subjected to Availability)

Course Title: Management in Engineering

Course Code:NE-3205

Credit Hour: 3.0

Course description

This is a course to introduce management-related knowledge required to the field of engineering, especially in Nuclear Engineering. Here, management is studied as a separate and independent body of knowledge that is crucial for running any type of organization in today's world. The course aims at giving students the managerial skills including knowledge and skills of management, communication, behavioral science, human resource management, project management, and management information systems. The prime objective of this course is to equip the engineering students to be more effective and efficient.

Learning outcomes

After completing this course the students should be able to understand:

- The concept of organization, its functions & departmentalization
- Forms of organization and its scope
- Concept of management and its importance as an independent body of knowledge
- Management functions and its cycle
- Management orientation & its viewpoints
- Scientific management and management tools & techniques
- Concept of communication and its importance in today's organization
- Communication knowledge & skills
- Drafting messages, memos, notes, and reports
- Human behavior and individual differences
- Behavioral studies and researches
- Motivational theories and practices
- Team and leadership
- Human resource functions
- Career planning and succession planning
- Project management and its importance in engineering

- Project management tools and techniques
- Project scheduling and optimizing
- Concept of MIS and its applications in engineering
- ERP and enterprise collaboration etc.

Course syllabus

Topic	Contents
Organization & its Functions	Concept of organization, functions of organization, organogram, concept of authority, responsibility, public & private organization, profit & not for profit organization, types of ownership, accountability, formalization, departmentalization, cost center & revenue center etc.
Management Functions	Definition, planning organizing, directing, controlling, coordinating, types of management, organization definition, planning, design and development, types of organizations, classical, new classical and modern principles, general management, scientific management, engineering management, systems management, procedures, resources and constraints, objectives, goals, policies and procedures, setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.
Management and Communication	Communication in today's workplace, team skills and interpersonal communication, using verbal and nonverbal message, listening and responding, writing messages, report writing, oral presentation, interview skills, email etc.
Organizational Behavior	Behavioral science and its importance, behavioral research, understanding self and others, personality & perception, multi-culture & diversity, organizational rewards, power & conflict, work-life balance, motivational theories etc.
Human Resource Management	Selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining, leadership and teams etc.
Project	Introduction, concept of a project, project management concepts,

Topic	Contents
Management	project simulation, cost or project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing), project evaluation.
Management Information Systems	Role of information, management information system and decision support system, information technology, introduction to e-business, e-commerce and integration tools like Enterprise Resource Planning (ERP).

Course components (Learning activities)

Lecture, discussion, group study, case study, problem solving, assignment, presentation etc.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination/Quiz	20
Semester Final Examination	70

Course schedule

Classes/week	Date: Week(Classes)	Topic	Reference
	W-1	Organization & its Functions	
	W-2	Organization & its Functions	
	W-3	Management Functions	
	W-4	Management Functions	
	W-5	First Incourse Examination	W-1, 2, 3 & 4
	W-6	Organizational Behavior	
	W-7	Organizational Behavior	

	W-8	Human Resource Management	
	W-9	Human Resource Management	
	W-10	Second Incourse Examination	W-5, 6, 7 & 8
	W-11	Project Management	
	W-12	Project Management	
	W-13	Management Information Systems	
	W-14	Management Information Systems	
	W-15	Final Examination	All

Recommended Readings

- S. P. Robbins, M. K. Coulter, Management, 11th Illustrated Edition, Pearson Education, Limited, 2012, ISBN: 9780273752776.
- Raymond V. Lesikar, John D. Pettitt, Jr. and Marie E. Flatley, Basic Business Communication, Irwin, Chicago, USA.
- S.P. Robbins, Organizational Behavior, Prentice-Hall India Ltd., New Delhi, India
- Gary Dessler, Human Resources Management, Prentice Hall of India Pvt. Ltd. New Delhi, India
- George E. Dieter, George Ellwood Dieter, Linda C. Schmidt, Engineering Design, 5th Illustrated Edition, MCGRAW-HILL Higher Education, 2012, ISBN: 9780071326254.
- C F Gray, E W Larson, Project Management: The Managerial Process, McGraw-Hill/Irwin, 2005, ISBN: 0071244466.
- Laudon K C, and Lane P. Laudon, Management Information Systems: Managing the digital firm, Prentice Hall, India.
- Understanding Business, 10th ed., McGraw-Hill Education, 2013, William G. Nickels, James M. McHugh, Susan M. McHugh. ISBN: 007352459x.
- Pederson, E.S., Nuclear Power: Nuclear power project management, Volume 2, Illustrated Edition, Ann Arbor Science Publishers, 1978, ISBN: 9780250402311.
- Hajek, V. G., Management of Engineering Projects, 3rd Edition, McGraw-Hill, 1984, ISBN: 9780070255364.

Course Title: Nuclear Power System Design Project

Course code: NE-3206

Credit: 1.5

Course description:

Students will design and build components or systems related to nuclear power plants for operation, control, and maintenance. They will gain practical experiences during their project work.

Learning Outcomes:

The students will be able to design, build, instrumentation and measurement of a particular component, structure and system to verify theory and operation principle practically.

Course Components (Learning Activities):

Design, building and operation of selected project, report writing, presentation and viva-voce.

Assessment Type

Activities	Percentage (%)
Attendance	10
Project demonstration	40
Project report	25
Presentation based on project set up	25

Course Schedule:

One class 3-hour duration per week. Total number of classes will be 14 weeks in one semester.

Course Title: Automation and Control Engineering

Course Code: 3207

Credit Hour: 3.0

Course description

This course is designed to enable the students to achieve an in-general conceptual knowledge of control and automation systems. The course mainly focuses on the different types of control systems, their response, configuration, and different methods to solve related problems. Analysis of manipulators will help students to understand basic mechanism and classification of robotics.

Learning outcomes

After completing this course, the students should be able to:

- Understand the objective, definition and different aspects control system in engineering application.
- Explain the basic control systems.
- Describe different methods of solutions.
- Illustrate the knowledge of manipulators

- Understand the nuclear kinematics of different manipulators.
- Be familiar with the elements control and automation systems.

Course Syllabus

Introduction	System, control system, input, output, Elements of a general control system, examples of control system, System configuration (Open-loop and closed loop), Design process.
Modeling in the frequency domain	Review of Laplace transform, impulse, step and ramp functions, Electrical, mechanical, rotational, electromechanical systems
Modeling in the time domain	State space representation, Converting a transfer function to state space
Time response	First order system, General second order system, Underdamped second order systems, System response with additional poles, zeros, Laplace solution of state equation, Time domain of state equation
Reduction of multiple orders	Block diagrams, Analysis and design of feedback systems, Mason's rule, Signal flow graphs of state equations
Manipulators	Classification of robot example of robot application, Identification of manipulator components and terminology; joints classification.
Kinematics	Kinematic description of multi-degree of freedom manipulators, Joint coordinates, task coordinates, transformation coordinate system, Kinematic model, dynamic equation of six degree of freedom robot arm, Introduction to Jacobians and dynamic performance, Automation strategy, Role of automation in industries, benefits of automation, Introduction to automation tools , programmable logic control (PLC), microcontroller, relay etc.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
Incourse Examination	15
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Introduction
	2 nd -4 th (6)	Modeling in the frequency domain
	5 th (2)	Modeling in the time domain
	6 th -8 th (6)	Time response
	9 th -10 th (4)	Reduction of multiple orders
	11 th (2)	Manipulators
	12 th -14 th (6)	Kinematics
	5 th Week	1 st in course examination
	11 th Week	2 nd in course examination

Recommended Readings

- Norman S. Nise, Control System Engineering, 6th addition, 2016. ISBN: 9780470547564
- Francis H. Raven, Automatic Control, 5th Edition, McGraw Hill, 1994. ISBN: 0070513414.
- Richard C. Dorf, Modern Control System, 11th Edition, Prentice Hall, 2007. ISBN: 0132270285.
- B. B. Kuo, Automatic Control Systems, 9th Edition, Wiley, 2009. ISBN: 0470048964.
- D. Roy Choudhury, Modern Control Engineering, Illustrated Edition, PHI Learning Pvt. Ltd., 2005. ISBN: 9788120321960.
- Katsuhiko Ogata, Modern Control Engineering, Prentice Hall, 2010. ISBN: 9780136156734.
- U. A. Bakshi, V. U. Bakshi, Control System Engineering, Technical Publications, 2008. ISBN: 9788184314632.
- L. C. Westphal, Handbook of Control Systems Engineering, Illustrated Edition, Springer, 2001. ISBN: 9780792374947.

Course Title: Industrial Training**Course code: NE-3208****Credit: 1.5****Course description:**

Students will be dispatched in the relevant industries such as different establishments of Bangladesh Atomic Energy Commission, Bangladesh Atomic Energy Regulatory Authority, Nuclear Power Company of Bangladesh Limited and thermal power stations for gathering real life experiences.

Learning Outcomes:

Students will be able to learn about the recent advancement of research and development activities of nuclear science and technologies with their class room knowledge. They will be able to find their career prospective after graduation.

Course Components (Learning Activities)

Experiments, Data collections, Theory studies, Presentation, Viva-voce, Report writing

Assessment Type:

Activities	Percentage (%)
Industry supervisor evaluation	40
Report	30
Viva-voce	30

Course Schedule:

Three-week intensive training at the dispatch institutes.

Course Title: Biomedical Applications of Nuclear Technology**Course Code: NE-3209****Credit: 3.0****Course description**

This course is designed to facilitate the students to acquire a thorough idea of basic principles of nuclear medical equipments and the physics behind the technology. The course mostly focuses on the production, absorption and utilization of radiopharmaceuticals via various radiation imaging techniques. Special attentions are given in dose calculation methodologies as well as in planning of treatment for patients. The course also covers electron beam therapy and brachy therapy to obtain a thorough understanding of radiation oncology. The students should have a basic knowledge of nuclear physics, radiation science and health physics in order to complete this course effectively.

Learning outcomes

After completing this course the students should be able to

- Explain the utilization of radiopharmaceuticals in the field of nuclear medicine.
- Fluently describe the basics of nuclear medicine, including gamma camera and collimators.
- Perform radiation dose calculations of various types.
- Be familiar with the planning of treatment for patients in the field of nuclear medicine.
- Have a thorough understanding of various imaging techniques including SPECT, CT, PET, MRI and X-rays.
- Depict the principles of Electron Beam Therapy and Brachy Therapy in the field of radiation oncology.

Course syllabus

Topic	Contents
Introduction to Radiopharmaceuticals	Radiopharmaceuticals, production of radioisotopes, radioisotope generators, radiopharmaceutical dosimetry, formulation of radiopharmaceuticals for different organs, radiopharmaceutical quality control & quality assurance procedure.
Nuclear medicine	Introduction to nuclear medicine, collimators: types and applications, quality control considerations in collimators, non-imaging probes, gamma camera and its components, quality assurance of gamma camera equipment, maintenance considerations, major indication & interpretation of imaging for different body organs & functions, role of computers in nuclear medicine imaging procedures, solid state gamma cameras, different methods of imaging, principles of image formation.
System of dosimetric calculation	Dose calculation parameters, collimator scatter correction factor, phantom scatter correction factor, tissue-phantom and tissue-maximum ratios, scatter –maximum ratios, accelerator calculation, cobalt -60 calculation, practical methods of calculating depth dose distribution.
Treatment planning	Isodose distribution, patient data, corrections and setup, field shaping, skin dose and field separation.
Radiation Imaging	SPECT, CT, PET, MRI, X-rays, Radiotracer, Radioisotopes.
Electron beam therapy	Electron interactions, energy specification and measurement, determination of absorbed dose, characteristics of clinical electron beams, treatment planning.
Brachy therapy	Radioactive sources, calibration of brachytherapy sources, calculation of dose distributions, systems of implant dosimetry, computer dosimetry system.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In-course Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (3)	Introduction
	2 nd – 4 th (4)	Nuclear medicine
	4 th – 6 th (4)	System of dosimetric calculation
	6 th -8 th (4)	Treatment planning
	8 th – 11 th (6)	Radiation Imaging
	11 th – 12 th (3)	Electron beam therapy
	13 th – 14 th (4)	Brachy therapy
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Sorenson, J. A. and Phelps, M. E. Physics in Nuclear Medicine, 3rd edition Grune and Stratton, 2003.
- Henkin R. E. et. al., Nuclear Medicine, Vol-I & II, Mosby Publishing Co., 1996.
- Society of Nuclear Medicine, MIRD Primer for Absorbed Dose Calculations, Revised edition, Society of Nuclear Medicine 1991.
- Society of Nuclear Medicine, MIRD: Radionuclide Data and Decay Schemes, Revised edition, Society of Nuclear Medicine, 1989.
- Gelfand& Thomas, Effective Use of Computers in Nuclear Medicine, McGraw Hill Book Company, USA, 1988.
- Williams L. (Editor), Nuclear Medical Physics, 3 volumes, CRC Press, 1987.
- Edward L. Alpen, Radiation Biophysics, 2nd Edition, Academic Press (1998), ISBN: 9780080540207.
- Faiz M. Khan, The Physics of Radiation Therapy, 4th Edition, Lippincott Williams & Wilkins, 2012, ISBN: 9781451149135.
- James E. Turner, Atoms, Radiation, and Radiation Protection, John Wiley&Sons, Inc. (2008), ISBN: 9783527616985.

- [Frank Herbert Attix](#), Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons, 2008, ISBN: 9783527617142
- [Marie Claire Cantone](#), [Christoph Hoeschen](#), Radiation Physics for Nuclear Medicine, Illustrated Edition, Springer, 2011, ISBN: 9783642113277
- Ervin B. Podgorsak, Radiation Physics for Medical Physicists, Springer, 2010, ISBN: 9783642008757.

FOURTH YEAR FIRST SEMESTER:

Course Title: Research Thesis/Project

Course code: NE-4000

Credit: 4

Course description:

Students will be asked to identify research problems by making questions for the advancement of nuclear science and engineering. Based on the problem, students will do literature studies, apply suitable materials and methodology (theoretical, experimental, and computational) data collections, data analyses, results and discussions and then finally preparing the thesis report. After literature studies and fixing the methodology, the identified problem will be solved theoretically, experimentally, and computationally (using software).

Learning Outcomes:

The learning objectives for a thesis are based on the objectives for Bachelor of Science in nuclear engineering. To find out a scientific and engineering problem and to know how to solve that problem based on research methodology.

Course components (Learning activities)

Presentation, Viva-voce and thesis report writing

Assessment Type

Activities	Percentage (%)
Thesis defence and Viva-voce	50
Thesis report evaluation	50

Course Schedule:

Students will meet with the respective thesis supervisors at least two days per week.

Course Title: Environment and Nuclear Disaster Management**Course Code: NE-4101****Credit Hour: 3.0****Course description**

This course is designed to enable the students to achieve an in-general conceptual knowledge of environment impact of nuclear already occurred and probable nuclear disaster as well as corresponding management system. The course mainly focuses on the different aspects of nuclear disaster, environment monitoring, environment exposure and analysis of previous nuclear accidents. Analysis and management of associated risk with the NPPs are considered with special importance. The disaster management and risk analysis with respect to the perspective of Bangladesh is also covered in this course. The students are expected to have the conceptual basics of nuclear reactor, effect of radiation exposure and associated topics.

Learning outcomes

After completing this course, the students should be able to:

- Understand the objective, definition and different aspects of disaster management,
- Explain the IAEA safety standards and guide related to disaster management and environment monitoring.
- Describe the environment monitoring objective, programs and associated equipment.
- Illustrate the environment exposure due to different effluents, their effects and mitigation measures.
- Understand the cause and effects of previous nuclear disaster and emergency response plan in case of nuclear accident.
- Be familiar with environmental impact assessment and economic analysis of disaster management.
- Gain an idea on risk assessment, risk analysis and risk management.
- Perform the risk-benefit and cost-benefit analysis.
- Analyze the disaster management and risk assessment in perspective of Bangladesh.

Course syllabus

Introduction	• Primary objective and the Theory of Disaster Management (DM); • The Problems of a Standard DM Response; • Nuclear DM; • Basics of IAEA Safety standards and guides for DM in NPPs.
Environmental monitoring	• Basics of IAEA Safety standards and guides for environmental monitoring of NPPs; • Environmental radiological monitoring and surveillance requirements during NPP Construction, Operation and Decommissioning; • Introduction to radioactivity monitoring equipment, analytical methods and their techniques; • Evaluation and monitoring of radiation level in air, water and soil in the vicinity (15-30 km distances) of the NPPs; • Public awareness systems during reactor operation, maintenance, and decommissioning periods; • Environmental monitoring program of the regulatory body and the operators; • National monitoring system of the radioactivity.
Environmental exposure	• Radioactive effluents from nuclear power plants and other related nuclear industries; • Effects of pollutants, dispersion of pollutants released to the atmosphere, water bodies and soil; • Re-concentration of pollutants in the food chain and critical pathways to man, • Social aspects of environmental hazards; • Sampling and monitoring of pollutants in various matrices methods of pollution control.
Nuclear Disaster Analysis	• Overview of history of Nuclear Disaster (Hiroshima and Nagasaki, Three Mile Island (TMI), Chernobyl, Tokaimura, Fukushima); • Accidental analysis of principle nuclear disaster; • Economic analysis of mitigation measures.
Disaster Management	• Environmental impact assessment methodology due to contamination of air, water and soil in case of accidents or higher level of radiation; • Mitigation measures based on the already occurred nuclear disaster; • National emergency response plan and coordination in case of nuclear accident.
Risk analysis	• Concepts of risks, risk assessment, risk analysis and risk management • Risk analysis for nuclear reactors and various stages of the nuclear fuel cycle; • Comparison of nuclear risks to risks from other energy sources; • Risk assessment methodology; • Risk-benefit and cost-benefit analysis; • Thermal ecological studies, biodiversity conservation studies, Geomorphology, geology and seismic studies.
Conclusion	• Environment and disaster management system in perspective of Bangladesh • Social awareness public and perception with respect to associated nuclear disaster probability and risk assessment.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
Incourse Examination	15
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1st (2)	Introduction
	2nd-4th (6)	Environmental monitoring
	5th-6th (4)	Environmental exposure
	7th-8th (4)	Nuclear Disaster Analysis
	9th-11th (6)	Disaster Management
	12th-13th (4)	Risk analysis
	14th (2)	Conclusion
	5th Week	1st in course examination
	11th Week	2nd in course examination

Recommended Readings

- Masters, G. M., Introduction to Environmental Science and Technology, Illustrated Edition, John Wiley, 1974. ISBN: 9780471576075.
- Eichholz, G. G., Environmental Aspects of Nuclear Power, Ann Arbor Science, Inc., 1976.
- Strauss, W., Air Pollution Control, Part I and II, Wiley-Interscience, 1971 & 1972.
- Eisenbud, M., Gesell T. F., Environmental Radioactivity, 4th Edition, Academic Press, 1997. ISBN: 9780080505800.
- Williamson, S. J., Fundamentals of Air Pollution, Illustrated Edition, Addison-Wesley, 1973. ISBN: 9780201086294.
- Inhaber, H., Energy Risk Assessment, Illustrated Edition, Taylor & Francis, 1982. ISBN: 9780677059808.
- McCormick, N. J., Reliability and Risk Analysis, Methods and Nuclear Power Applications, Academic, 1981.

- Green, A. E., Safety Systems Reliability, Illustrated Edition, Wiley, 1983. ISBN: 9780471901440.
- Lakner, A. A. and RT. Anderson, Reliability Engineering for Nuclear and other High Technology Systems, Elsevier 1985.
- Billinton, R, and R N. Allan, Reliability Evaluation of Engineering Systems: Concepts and Techniques, 2nd Edition, Springer, 1992. ISBN: 9780306440632.
- IAEA Safety Standards, “Radiation Protection Aspects of Design for Nuclear Power Plants for protecting people and the environment” No. NS-G-1.13
- IAEA Safety Standards, “Environmental and Source Monitoring for Purposes of Radiation Protection for protecting people and the environment” No. RS-G-1.8
- IAEA Safety Standards; Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards” No. GSR Part 3
- IAEA Safety Standards, “The Management System for Facilities and Activities for protecting people and the environment” No. GS-R-3

Course Title: Nuclear Power Plant Design and Features

Course Code: NE-4103

Credit: 3.0

Course description

This course is designed to facilitate the students to attain a thorough idea of how the nuclear power plant is designed, operated and controlled. The course mostly focuses on the typical core design requirements, design variables & constraints, design codes and procedure, basics of LWRs design; structure, function and working principles of the components of primary and secondary circuits; control of reactor during startup, normal operation and shutdown; plant maintenance and outage. The course also covers the topics of grid substation and power plant economics. To get an experience of reactor operation, students will carry out plant analysis in the case of normal operation, plant transient and accident condition using plant simulator available in the department. The students are required to have basic knowledge of reactor physics, thermal hydraulics/thermal engineering and materials science in order to complete this course effectively.

Learning outcomes

After completing this course the students are expected to be able to

- Explain the objectives of core design, design variables and constraints, function and mutual dependency of different areas of core design, equations for reactor calculation, calculation algorithm, design codes, basics of PWR & BWR design.
- Discuss the various components of primary circuit and working principle of different systems (auxiliary, safety etc) of LWRs.

- Demonstrate the function; working principle and the maintenance of the secondary circuit's components specially steam turbine and generator.
- Understand the operation and control of nuclear power plant viz. plant startup, operation mechanism, cooling in power operation, shut down cooling, plant shutdown, refueling, maintenance & plant outages.
- Describe the different types of transformer, switch gear and circuit breaker used in nuclear power plant and grid substation.
- Be familiar with the economics of nuclear power plant.
- Calculate the core multiplication, critical mass, critical size of reactor, number of fuel rods and assemblies, batch size, annual fuel loading, cooling requirements, different thermal hydraulic parameters, pumping power, flow rate, shut down margin, decay heat generation, depletion and production of various isotopes during reactor operation, reflector savings, shielding requirement, thickness of pipe and vessel, capacity factor & plant availability, generation cost etc.
- Illustrate the different states of plant operation; analyze plant transient and accident conditions.

Course syllabus

Topic	Contents
Nuclear power plant design	Principles of nuclear reactor design, safety parameters of reactor, general aspects of core design, core design objectives, core design constraints and variables, nuclear design, thermal hydraulic design, mechanical/material design, design of reactor shielding and reflector. Light Water Reactor (PWR & BWR) Design- general core design, core design set-up, design of fuel lattice and assembly, characteristics of reactivity, control of power distribution, core management, fuel management.
Primary circuit	Light water reactor components & system- core internals, reactor pressure vessel, primary coolant pump, pressurizer, steam generator, steam separator & dryer, ECCS, CVCS, SLCS, RHRS, containment spray system etc.
Secondary Circuit	Steam turbine - HP, IP & LP steam turbines, supersonic nozzle, turbine governor valves, journal bearing, lube oil temperature control, axial thrust & vertical thrust, thermal expansion of turbine casing, turbine trip, generator & accessories.
Operation and control of nuclear power plant	Plant startup- types, startup from cold zero power to hot full power, pressure, temperature, reactivity control during startup, limiting conditions for startup, startup sequence, operational issues during startup, safety issues during startup, synchronization of the generator. Normal plant operating

	parameters, plant heat balance & the steam cycle, operation mechanism of PWR & BWR. Reactor cooling in power operation, shut down cooling. Plant shutdown, refueling, maintenance & plant outages.
Grid substation	Unit transformer, Auxiliary transformer and distribution transformer, high tension switches gear, low tension switchgear, ACB, MCCB & operation mechanism of SF6.
Nuclear power plant economics	Cost components of nuclear power project, cost comparison of nuclear & fossil fuel plants, future trends in nuclear power cost
Plant simulators & operating training.	Normal operation, transient analysis, accident analysis

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment type

Activities	Percentage (%)
○ Assignment/Presentation	5
○ Class Attendance	5
○ Incourse Examination	20
○ Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 5 th (10)	Nuclear power plant design
	6 th – 7 th (3)	Primary circuit
	7 th – 8 th (3)	Secondary Circuit
	9 th -11 th (6)	Operation and control of nuclear power plant
	12 th (2)	Grid substation
	13 th (2)	Nuclear power plant economics
	14 th (2)	Training on plant simulator
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Nuclear Reactor Analysis, James J. Duderstadt and Louis J. Hamilton, 1st ed. New York: Wiley, 1976. ISBN: 9780471223634
- Nuclear Reactor Design, Oka.Yoshoaki, Springer, 2014, ISBN 978-4-431-54897-3
- Nuclear Reactor Engineering, Glasstone and Sesonske, Third ed.

- Applied Reactor Technology, Henryk Anglart, 2011
- Elementary Introduction to Nuclear Reactor Physics, S.E. Liverhant, 2nd ed.
- A Guide to Nuclear Power Technology, F. J. Rahn, A. G. Adamantiades, J. E. Kenton, and C. Braun, John Wiley and Sons, 1984.
- Power Plant Engineering, Nage, 3rd edition, Tata McGraw Hill
- Introduction to Nuclear Engineering, John R. Lamarsh, Anthony J. Baratta, Third Edition, Chapter 4, ISBN 0-201-82498-1.
- Introduction to Nuclear Power, Hewit & Collier, 2nd ed.
- Nuclear Engineering Handbook, Kenneth D. Kok, ISBN 978-1-4200-5390-6
- Power plant Engineering, Dasgupta, 3rd edition, MC Graw Hill
- Power plant Engineering, Wakill, 1st edition, PRI
- Power plant Technology, El-Wakil, McGraw-Hill, 1984

Course Title: Research Methodology, Scientific, and Technical Writing

Course Code: NE- 4105

Credit: 2.0

Course Description

Specific Objectives

- Understand some basic concepts of research and its methodologies, characteristics
- Identify appropriate research topics
- Select and define appropriate research problem and parameters
- Prepare a project and research proposals (to undertake a project/research) and how to organize and conduct research in a more appropriate manner
- To develop skills related to professional communication and technical & scientific writing.

Learning Outcomes

After completing the course the students will be able to:

- formulate purpose statements and research- or investigation questions;
- choose strategies and methods in concordance with research- or investigation questions, and motivate and explain these choices;
- conduct literature studies;
- plan surveys, collect survey data, and analyze survey data using statistical data analysis techniques;
- plan interviews, execute interviews, and interpret interview data using qualitative techniques;
- identify the key components of scientific and technical style, and the pitfalls associated with that style
- Explain the similarities and differences between three genres of technical and scientific writing (thesis, dissertation, reports, papers or articles, and manuals or

instructions)

- Identify the structural, style and audience factors that need to be borne in mind when writing reports/articles/papers/manuals/instructions
- Model phenomena and their relationships as dependent and independent variables, formulate hypotheses using variables, develop instrumentation for measurement of either technical qualities or social phenomena, conduct experiments to collect data, verify or refute hypothesis using statistical data analysis techniques;
- Write arguing prose that is coherent, clear, and concise with appropriate use of citations, and review such prose for the same qualities;
- Organize scientific publications and professional investigations.

Course Syllabus

Definition of research, types of research, Fundamental research, applied research, Engineering research, Methodologies to solve engineering problems, Research proposals, Research planning, Legal research, Copyright, Research ethics, Making effective Charts, Graphs, Tables, How to write scientific papers/report/thesis, Articles, Preparing government documents, Presentation skills, Communication skills, Editing and Proofreading strategies.

Course Component (Learning Activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
In course Examination	20
Semester Final Examination	70

Class schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Definition of research, types of research, Engineering research
	2 nd – 3 rd (4)	Methodologies to do engineering research, Descriptions and characteristics of Theoretical, Experimental and Computational research.
	4 th – 5 th (4)	Method of data collections, data analyses and uncertainty analyses, Survey, Interview methods
	6 th -8 th (6)	Document review and Observation methods, Case

		studies, Case studies formation, Case study exercises.
	9 th -11 th (6)	Research planning, research proposals, Budget preparation, Legal research, Copyright, Plagiarism
	12 th -14 th (6)	Thesis/Dissertation writing, Paper writing format, Literature review, Citation styles, Presentation skills, Paper review structure.
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Reading

- An introduction to Research Method, Third edition- M. Nurul Islam.
- Research Methods in Social Science- Dr. Neaz Ahmed.
- Research planning & proposal writing skill- Dr. Subrota Kumar Saha.
- C.R Kothari, *Research Methodology: Methods & Techniques*, New Age International Publishers.
- R. Panneerselvam, *Research Methodology*, Prentice Hall of India, New Delhi, 2012.
- K.N.Krishnaswamy, AppalyerSivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education.
- Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases*, Vikas Publishing House.
- J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
- Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
- Willktnsion K.L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.

Course Title: Fusion Power Engineering

Course Code: NE-4107

Credit Hour: 3.0

Course description

This course is designed to facilitate the students to acquire a thorough idea offusion engineering and plasma formation. The course mostly focuses on Fusion power generation and power balance in a fusion reactor. The course also covers Fusion confinement,Fusion reactor blanket material and design of a simple magnetic fusion reactor.In terms of prerequisites, my assumption is that students will have a solid foundation in undergraduate physics and mathematics. The specific requirements include: mathematics up to partial differential equations, mechanics, basic fluid dynamics, and electromagnetic theory (i.e., electrostatics, magneto-statics, and wave propagation).

Learning outcomes

After completing this course the students should be able to

- Understand the role of fusion energy, Fusion reactions, difficulty of fusion reaction and thermonuclear conditions of fusion reaction.
- Explain the fusion cross section, reaction rate, Lawson criteria fusion power density and radiation losses.
- Describe the power balance in magnetic fusion reactor.
- Get idea about basics of plasma physics and start-up and burning plasma analysis.
- Illustrate the Fusion confinement, tokamak and stellarator concept.
- Depict the Blanket concept of fusion reactor, plasma wall interactions, radiation damage to material.
- Be familiar with Fission-fusion hybrids reactor, prospect of ITER.
- Calculate the critical fusion reactor design parameter.

Course syllabus

Topic	Contents
Fundamentals of fusion engineering	The role of fusion energy, Fusion reactions, difficulty of fusion reaction, fusion in sun and stars, fusion fuel cycles, energy partition in fusion reaction, thermonuclear conditions; Lawson and ignition criteria, basic concept about plasma formation, start-up and burning plasma analysis, Magnets: superconductivity.
Fusion power generation	Concept of cross section, mean free path, and collision frequency, reaction rate, distribution functions, fusion cross sections, fusion power density and radiation losses.
Power balance in a fusion reactor	0-D conservation of energy relation, general power balance in magnetic fusion, steady state power balance, power balance in the plasma, power balance in a reactor, time dependent power balance in a fusion reactor.
Fusion confinement	Necessity of confinement, Material confinement, gravitational confinement, electrostatic confinement, inertial confinement: Energy balance, compression energy, laser and particle beam drivers; magnetic confinement: energy and particle flow in magnetic field, linear mirror fusion concept, tandem mirror, tokamak concept and stellarator concept.
Fusion blanket	Blanket concept, first wall loading, plasma wall interactions, wall impurity effects, blanket neutronics and energetics, tritium inventory, methods of recovery, tritium breeding induced radioactivity, radiation damage to material: influence on design.
Design of a simple magnetic fusion	Generic fusion reactor, critical reactor design parameter, design goals, and basic engineering and nuclear physics

reactor	constraints, design of the reactor, Fission-fusion hybrids reactor, prospect of ITER.
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Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class

Assessment type

Activities	Percentage (%)
○ Assignment/Presentation	5
○ Class Attendance	5
○ In-course Examination	20
○ Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 3 rd (6)	Fundamentals of fusion engineering
	4 th – 5 th (4)	Fusion power generation
	6 th – 7 th (4)	Power balance in a fusion reactor
	8 th -10 th (6)	Fusion confinement
	11 th -12 th (4)	Fusion blanket
	13 th -14 th (4)	Design of a simple magnetic fusion reactor
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Plasma Physics and Fusion Energy, Jeffrey P. Freidberg, 2007.
- Principles of Fusion Energy, A.A. Harms, K.F. Schoepf, G.H. Miley, D.R. Kingdon, ISBN 981-02-4335-9
- Francis F. Chen, Introduction to Plasma Physics and Controlled Fusion. Springer; 2nd Ed., 1984
- Introduction to Nuclear Power, Geoffery F. Hewitt, Jhon G. Collier, 2nd edition, Chapter-9.
- John Wesson, Tokamaks, Oxford Univ. Press, USA, 4th edition, 2011
- Mitsuru Kikuchi, Karl Lackner, and Minh Quang Tran, Fusion Physics, IAEA, Vienna 2012
- Leslie C. Woods, Theory of Tokamak Transport, Wiley-VCH Verlag GmbH & Co. KGaA, 2006.
- Dwight Nicholson, Introduction to Plasma Theory, John Wiley & Sons, 1983.

Course Title: Introduction to Nanoscience and Nanotechnology**Course Code: 4109****Credit Hour: 3.0****Course description**

This course is designed to introduce and provide a broad view of the nascent field of nanoscience and nanotechnology to undergraduates. The course mainly focuses on the properties of nanomaterial, synthesis of nanomaterial and their applications in different scientific fields as well as in Nuclear Engineering sides. Students should understand the basic idea of Nanoscience and Nanotechnology that would help them to think about Nuclear Engineering from the perspective of Nanoscience and Nanotechnology.

Learning outcomes

There are quite different areas of using nanotechnology in the nuclear power industry. Students are expected to apply the knowledge in the corresponding fields of nuclear science and engineering:

- New nuclear fuel creation, the one that is high-density, and contains Nano-sized additives;
- Creation of Nano-disperse functional and construction materials, creation of MOX fuel;
- Development of metrological guarantee for using nanomaterial-based constructional and functional units of nuclear facility;
- Research and development of materials that will be used for creation of nuclear fusion reactors;
- Multi-scale modeling of nanostructures, processes and materials and so on.

Course syllabus

Introduction	• History of nanotechnology, • Advantages of nanotechnology, • Applications in Nuclear Engineering, • Overview of different nanomaterial available.
Introduction	• Difference between bulk and nanomaterial, • Properties of nanomaterial, • Influence of Nano structure on mechanical, optical, electronic, magnetic and chemical properties.
Nanomaterial synthesis	• Top-Down and Bottom-Up approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots) synthesis. • Self-assembly and Self-assembled monolayers, • Directed assembly, • Layer-by-layer assembly. • CVD,

	• PVD, • Sol- gel method • Etching- wet and dry method.
Pattern replication techniques	• Lithography techniques • Soft lithography, • Nano imprint lithography
Different types of Nanoparticles	• Quantum dot • Gold nanoparticles characteristics and applications • Silver nanoparticles characteristics and applications • Carbon nanotubes and applications in field emission displays.
Characterization Techniques	• SEM, • TEM, • HRTEM, • STM, • Raman spectroscopy.
Application of Nanomaterial	• Nano pharmaceuticals • Nanoparticle-based drug delivery • Nano biosensors, • Electronic-nano particles for molecular diagnostics, • Molecular motors, • Energy storage, • Handling, Safety and Hazard of Nanomaterial Processing.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Quiz, Sudden test and Problem-Solving Classes

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Quiz/ Sudden test	5
In-course Examination	15
Semester Final Examination	70

Class schedule

Date: Week (Classes)	Topic
1 st -2 nd (4)	Introduction
3 rd -4 th (4)	Properties
5 th -6 th (4)	Different types of Nanoparticles
7 th -8 th (4)	Application of Nanomaterial

Date: Week (Classes)	Topic
9 th -11 th (6)	Nanomaterial synthesis
12 th -13 th (4)	Pattern replication techniques
14 th (2)	Characterization Techniques
5th Week	1st in course examination
11th Week	2nd in course examination

Recommended Readings

- Nano composite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
- Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
- Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
- Micro and Nanofabrication, Zheng Cui, Springer 2005
- Nanotechnology and Nano electronics, W.R, Fahrner, Springer 2005
- Hand book of Nano science, Engineering, and Technology, William A. Goddard, CRC press 2003.
- Nanomaterial's: Risks and Benefits, Edited by Igor Linkov and Jeffery Steevens, Nato Science for Peace and Security Series-C, Environmental Security, Springer 2009.

FOURTH YEAR SECOND SEMESTER:

Course Title: Advanced Nuclear Reactors Design and Features

Course Code: NE-4201

Credit Hour: 3.0

Course Description

The objective of the course is to provide an overview of advanced nuclear reactor issues that influence on nuclear power safety, proliferation, wastes, fuel cycles and economy & environment. The topics which are covered in the course: concept of advanced nuclear reactor design and principles of; small modular reactors, Liquid metal cooled fast reactors, gas cooled fast reactors, high temperature engineering test reactors, molten-salt reactor, supercritical water reactor, both active and passive safety systems, proliferation, fuel cycles, waste management, cost economics and environmental issues of the advanced nuclear reactors.

Learning Outcomes

After completing this course the students should be able to

- Understand the concept of advanced nuclear reactor design specially Gen-IV
- Understand the safety characteristics, challenges, and potentiality of advanced reactors
- Compare the safety, proliferation, fuel cycles, wastes, cost and environmental issues of Gen-IV reactors with the Gen-II reactors.

Course Syllabus

- IAEA Definition of advanced NPPs, Definition of Advanced nuclear plant designs, Evolutionary designs and Innovative designs
- Fundamentals of SMR Designs, SMART, Salient features of the SMRs and SMART with respect to vendor and type of reactor (LWRs, HWRs, GCRs, FRs etc.)
- Introduction, Description of the Nuclear Systems, Description of Safety Concept
- Proliferation Resistance, Safety and Security (physical protection)
- Description of Turbine-Generator Systems, Electrical and I&C Systems
- Spent Fuel and Waste Management
- Plant Layout and Plant Performance
- Development Status of Technologies Relevant to the NPP, Deployment Status and Planned Schedule
- Cost economics, and Environmental issues in case of accident.

Course components (Learning activities)

Lecture, Discussion, Assignment, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 th (4)	Concepts of advanced nuclear reactors
	3 th – (2)	SMR technologies
	4 th – (2)	Proliferation Resistance, Safety and Security
	5 th – (2)	Description of RPV, Turbine, Generator
	6 th – (2)	Small size advanced reactor design

Class/week	Date: Week (Classes)	Topic
	7 th – (2)	Medium size advanced reactor design
	8 th – (2)	Environmental Impact in case of accident
	9 th – (2)	Large size advanced reactor design
	10 th – (2)	I & C Plant layout and Plant Performances
	11 th – (2)	Fuel cycles for advanced reactors
	12 th -13 th (4)	Waste management strategy for advanced reactors
	14 th (2)	Economics of advanced reactors and environmental issues
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Advances in small reactor modular technology developments, A Supplement to: IAEA Advanced Reactors Information System (ARIS) 2016 Edition
- Nuclear Reactor Analysis, James J. Duderstadt and Louis J. Hamilton, 1st ed. New York: Wiley, 1976. ISBN: 9780471223634
- Nuclear Reactor Design, Oka. Yoshiaki, Springer, 2014, ISBN 978-4-431-54897-3
- Advanced nuclear plant designs IAEA TECDOC-936 (1997)
- TECDOC-1536 Status of Small Reactor Designs Without On-site Refuelling.
- TECDOC-1485 Status of Innovative Small and Medium Sized Reactor Designs 2005: Reactors with Conventional Refuelling Schemes.
- TECDOC-1391 Status of Advanced Light Water NPPs.

Course Title: Reactor Operation and Experiments Lab

Course code: NE-4202

Credit: 1.5

Course description:

The course is based on the only 3MWth TRIGA Mark-II nuclear research reactor and its experimental features

Learning Outcomes:

The main objective is to learn how to operate nuclear research reactor for experimental purposes and to do experiments using different experimental facilities at 3MWth TRIGA Mark-II research reactor.

List of Experiments:

1. Thermal power calibration
2. Control rod worth measurement
3. Control rod calibration
4. Reactivity measurement
5. Radiation detection and measurement

Course Components (Learning Activities):

Study, Operation, and Experiments of 3MWth TRIGA Mark-II nuclear research reactor of Atomic Energy Research Establishment at Savar, Dhaka, Walkthrough, Presentation, and Analyses of reactor operational data and maintenance records.

Assessment Type:

Activities	Percentage (%)
Attendance	10
Continuous Assessment	50
Examination	20
Viva-voce	20

Course Title: Nuclear Safety, Security and Safeguards Issues

Course Code: NE-4203

Credit: 3.0

Course Description

This course is designed to assist the students to achieve an idea of nuclear safety, security and safeguards Issues. The course mostly focuses on the nuclear security and safeguards issues. The security section contains some definitions relevant to nuclear security, international protocols, and legal instruments, legal and regulatory framework, physical protection system, design basis threat analysis etc. The safeguard section includes treaties and safeguard agreement, safeguard policy and regulations, nuclear material accounting and control, safeguards reporting system, safeguards information system, safeguards verification systems etc. The course also covers the topic of nuclear safety where attention is given basically to IAEA safety standard series.

Learning Outcomes

After completing this course the students are expected to be able to

- Explain the difference among safety principles, safety requirements, safety guides.
- Discuss the various international instruments (binding and nonbinding) for nuclear security.
- Demonstrate the different categories of nuclear material, design and function of physical protection system, process of DBT analysis; motivation, intention and capabilities of outsider and insider threat; assessment methodology for nuclear security cultures
- Understand the regulation for nuclear material and radioactive sources in storage and transport, export and import control, Zangger committee trigger list, NSG guidelines.

- Describe the various treaties (e.g. NPT, NWFZT), safeguard agreement (e.g. CSA, VOA, Item Specific Safeguard Agreement) and protocol (AP, suspension protocol)
- Be familiar with the national regulatory framework for safeguards policy and regulation, nuclear material facility inspection guidance, nuclear material accounting and safeguard reporting system.
- Describe the safeguards information system, safeguards verification systems, and various in-field verification activities

Course Syllabus

Topic	Contents
Safety	Safety principles, safety requirements, safety guides, IAEA safety standard series for regulating and operating NPP and nuclear facilities.
Security	Definition of nuclear security; Threat, Theft, sabotage, Nuclear attacks, Historical developments, International Protocols, UNSCR-1373, 1540, IAEA nuclear security document Series and Hierarchy, Member state's obligations towards nuclear security, Legal and Non-legal binding instruments for member states, Legislative and regulatory framework for nuclear security, Physical protection regime and layers, graded approach, Category of nuclear material, Physical Protection System (PPS) designs for protection of nuclear material, radiation and associated facilities, Design Basis Threat (DBT) analysis, Detection architecture (Boarder, Airport, Sea port), Regulation for nuclear material and radioactive sources in storage and transport, Export and import control, Assessment methodology for nuclear security cultures, Insider threats analysis, cyber security, Nuclear security event response and neutralization.
Safeguard	History of nuclear nonproliferation, NPT, IAEA Safeguards systems, Evolving safeguards implementation, Safeguards agreements, additional protocol agreements, National regulatory framework for safeguards policy and regulation, nuclear material facility inspection guidance, State-level and integrated safeguards concepts, state systems accounting for and control (SSAC) of nuclear material, Safeguards reporting system, Safeguards information system, Safeguards verification systems, NDAs and DAs, Safeguards challenges for fuel fabrication, enrichment and reprocessing facilities, Safeguards R&D for advanced nuclear fuel cycles.

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Workshop

Assessment Type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 2 nd (3)	Nuclear safety, IAEA safety standard series safety series
	2 nd – 3 rd (3)	Nuclear security, Threat, Theft, sabotage, Nuclear attacks, nuclear security regime, Historical developments, IAEA nuclear security document Series and Hierarchy, International Protocols, UNSCR-1373, 1540, Member state's obligations towards nuclear security, Legal and Non-legal binding instruments for member states, Legislative and regulatory framework for nuclear security,
	4 th – 7 th (7)	Physical protection regime and layers, graded approach, Category of nuclear material, Physical Protection System (PPS) designs for protection of nuclear material, radiation and associated facilities, Design Basis Threat (DBT) analysis, Detection architecture (Boarder, Airport, Sea port), Insider threats analysis, cyber security, Nuclear security event response and neutralization.
	7 th - 8 th (3)	Regulation for nuclear material and radioactive sources in storage and transport, Export and import control, Assessment methodology for nuclear security cultures
	9 th -10 th (4)	History of nuclear nonproliferation, NPT, IAEA Safeguards systems, Evolving safeguards implementation, Safeguards agreements, additional protocol agreements etc
	11 th -12 th (4)	National regulatory framework for safeguards policy and regulation, nuclear material facility inspection guidance, State-level and integrated safeguards concepts, state systems accounting for and control (SSAC) of nuclear

		material, Safeguards reporting system
	13 th -14 th (4)	Safeguards information system, Safeguards verification systems, NDAs and DAs, Safeguards challenges for fuel fabrication, enrichment and reprocessing facilities, Safeguards R&D for advanced nuclear fuel cycles
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

IAEA safety standard series
IAEA security standard series
IAEA safeguard standard series

Course Title: Radiation Transport Safety and Shielding

Course Code: NE-4205

Credit Hour: 3.0

Course Description

This course is designed to facilitate the students to acquire a thorough idea of interaction of different types of radiation flux. It is designed to enable students to carry out calculations for a given source of radiation flux and medium, the interaction rate and attenuation and incorporate buildup in the final flux calculation.

Learning outcomes

After completing this course the students should be able to

- Understand and explain different types of possible interactions with matter for different forms of radiations
- Explain and derive the equation for attenuation of uncollided flux for different types of radiation sources; calculate HVL, TVL, mean free path, etc
- Demonstrate a basic understanding of the equation for radiation transport and reaction rate
- Demonstrate the application of empirical relationships to evaluate ranges for different forms of radiation
- Establish the connection between uncollided flux, buildup flux and exposure rate
- Derive and calculate the buildup flux for different types of sources
- Explain the basic principles behind shielding design
- Design shielding for different sources of radiation

Course Syllabus

Topic	Contents
Radiation interaction	Attenuation of neutral particle beams, calculation of radiation interaction rate, photon interactions, neutron interactions, interaction of heavy charged particles, interaction of fast electrons, interaction of gamma rays, radiation exposure and dose.
Radiation shielding	Isotropic and anisotropic shields for extended radiation sources, calculation methods used in shielding, effects of ducts and voids in shields, streaming and backscattering of radiation, heat generation by radiation in shields, materials for shielding and their nuclear, physical, and mechanical properties and technology, shield design and engineering research and power reactors, transport containers, reprocessing plants, waste storage facilities and shielded cells.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & Operating Training Using Plant Simulators

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st – 7 th (13)	Radiation interaction
	8 th –14 th (13)	Radiation shielding
	5 th	1 st Incourse Examination
	11 th	2 nd Incourse Examination

Recommended Readings

- Chilton, A B., Shultis, J. K. and R E. Faw, Principles of Radiation Shielding, Prentice-Hall, 1984.

- Glenn F. Knoll, Radiation Detection and Measurement, 4th edition, Illustrated, John Wiley & Sons, 2010, ISBN: 9780470131480.
- Schaeffer, N. M. (ed), Reactor Shielding for Nuclear Engineers, Technical Information Center, USAEC, 1973.
- Goldstein, H., Fundamental Aspects of Reactor Shielding, Pergamon, 1959.
- Rockwell, T., Reactor Shielding Design Manual, Springfield National Technical Information Services 1956.
- Jaeger, RG. and E.P. Blizard (eds.), Engineering Compendium on Radiation Shielding Vol. 1, 11 and, 111, Springer- Verlag, 1970

Course Title: Decommissioning Management and Procedure

Course Code: NEOP-4207

Credit Hour: 3.0

Course Description

This course is designed to facilitate the students to acquire a thorough idea about decommissioning of nuclear installation and decommissioning waste management. The course mostly focuses on decommissioning organization and management and also cutting and dismantling techniques of nuclear installation. Special attentions are given in safety, health and environmental protection. Decommissioning cost evaluation is also discussed in this course. The students should have a basic knowledge about spent fuel management, radiation science and chemistry in order to complete this course effectively.

Learning Outcomes

After completing this course the students should be able to

- Understand the decommissioning challenges and strategies.
- Explain the organization and management in the various phases of decommissioning.
- Describe the plant and site characterization.
- Illustrate the decommissioning waste management strategy and procedure.
- Learn about safety, health and environmental protection of personnel and general public.
- Be familiar with cutting and dismantling techniques of nuclear installations.
- Calculate the cost of decommissioning.

Course Syllabus

Topic	Contents
Nuclear Plants Decommissioning Overview	Definition and Scope of Decommissioning, Introduction to Some Decommissioning Challenges, Decommissioning Strategies, Decommissioning in the World,
Decommissioning	Issues Affecting Decommissioning Organization and

Organization and Management	Management, Organization and Management in the Various Phases of Decommissioning, Management for Active Phases of Decommissioning, Decommissioning Planning and Licensing, Nuclear site licensing.
Plant and Site Characterization	Initial Plant Characterization: Radioactivity Sources, The Concept and Extent of Characterization, Structure Characterization. Site Characterization: Surface and Subsurface Soil contamination, Surface Water and Groundwater Contamination.
Decontamination Techniques	Objectives of Decontamination Techniques, Selection of Decontamination Technologies, Survey of Applied Decontamination Techniques, Chemical, Mechanical Decontamination and Other Decontamination Techniques
Cutting and Dismantling Techniques	Overview of cutting techniques, Techniques of material cutting: Thermal Cutting Techniques, Hydraulic Cutting Techniques, Mechanical Dismantling Techniques, Remote Operation Technologies, Elements of robotic systems together with their integration and control, User interface design and implementation using the lab view software environment.
Decommissioning Waste Management	Overview, Clearance Levels, Radioactive species present in the decommissioning environment, Waste-Management Strategy, Treatment and Conditioning of different types of waste, Packaging, storing and Transport technologies.
Safety, Health and Environmental Protection	Instrument used to characterize radiation levels within decommissioning environment, Environmental Impact Assessment (EIA), Radiation effect on materials and electronics, Explosive in demolition.
Decommissioning Cost Evaluation	Regulatory and site infrastructure cost, Standard Criteria for Cost Evaluation, Cost Evaluation Methodologies, Cost Calculation Model Example, Cost-Breakdown Structure,

Course Components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & Operating Training Using the Lab View software

Assessment Type

Activities	Percentage (%)
○ Assignment/Presentation	5
○ Class Attendance	5
○ Incourse Examination	20
○ Semester Final Examination	70

Course Schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	Nuclear Plants Decommissioning Overview
	2 nd – 3 rd (4)	Decommissioning Organization and Management
	4 th – 5 th (4)	Plant and Site Characterization
	6 th -7 th (4)	Decontamination Techniques
	8 th -9 th (4)	Cutting and Dismantling Techniques
	10 th -11 th (4)	Decommissioning Waste Management
	12 th -13 th (4)	Safety, Health and Environmental Protection
	14 th (2)	Decommissioning Cost Evaluation
	5 th	1 st In-course Examination
	11 th	2 nd In-course Examination

Recommended Readings

- Handbook of Nuclear Engineering, Dan Gabriel Cacuci, Volume-5, Springer publication.
- Cutting techniques for facilities dismantling in decommissioning projects, Paulo E. O. Lainetti, International Nuclear Atlantic Conference - INAC 2011, Belo Horizonte, MG, Brazil, October 24-28, 2011, ISBN: 978-85-99141-04-5.
- A Guide to Nuclear Power Technology, Frank J. Rahn, A.G Adamantiades, J.E Kenton and Chaim Braun, John Wiley & Sons 1984
- Introduction to Nuclear Engineering, John R. Lamers& Anthony J. Barata, 3rd edition, Prentice Hall, 1982
- Decommissioning of Nuclear Power Plants and Research Reactors, IAEA safety standards series, No. WS-G-2.1.

Course Title: Radiation Imaging

Course Code: NE-4209

Credit: 3.0

Course Description

This course is designed to facilitate the students to attain a thorough idea about various radiation imaging techniques. The course mostly focuses on linear imaging systems, image transformation, sampling and radiation imaging. The course also covers the topic of ultrasound imaging techniques. The students are required to have basic knowledge of linear

algebra, differential equations, probability and statistics, calculus, nuclear radiation detection and digital electronics in order to complete this course effectively.

Learning Outcomes

After completing this course the students are expected to be able to

- Explain the fundamentals digital imaging and its application in radiation imaging.
- Understand linear imaging system, image transformation and sampling.
- Discuss different radiation imaging techniques.
- Compare various radiation imaging techniques.
- Be familiar with ultrasound imaging.
- Perform basic Image transformations.

Course Syllabus

Topic	Contents
A brief introduction to tomographic imaging	Introduction to general imaging principles, imaging terms and definitions linear optics (ray tracing).
Linear imaging systems	The delta function and the impulse function superposition, instrument response function, point spread function, space invariance, pin-hole camera.
Fourier transform	Fourier transformations, modulation transfer functions, convolution, deconvolution, fourier convolution.
Sampling	Sampling, Nyquist, counting statistics, additive noise.
Sound imaging	Coherent imaging & ultrasound, ultrasound imaging, ultrasound contrast, microscopy and Doppler.
Radiation imaging	Radiation types, interactions, radiation detection, dose, planar x-ray imaging, system response, s/n, projective imaging, back projection, shadow imaging, bp and 2-d resolution, x-ray ct, spect, pet, basics of NMR, pulses and relaxation times, echoes & k-space, echoes and contrast, 2-d gradient and spin echoes, selective pulses, 3-d methods of MRI volume localized spectroscopy, flow / diffusion MRI.

Course components (Learning activities)

Lecture, Discussion, Interactive Tutorial, Problem Solving Class & Simulation using MATLAB.

Assessment type

Activities	Percentage (%)
Assignment/Presentation	5
Class Attendance	5

Activities	Percentage (%)
Incourse Examination	20
Semester Final Examination	70

Course schedule

Class/week	Date: Week (Classes)	Topic
2	1 st (2)	A brief introduction to topographic imaging.
	2 nd -3 rd (4)	Linear imaging systems.
	4 th – 6 th (6)	Fourier transform.
	7 th (2)	Sampling.
	8 th – 10 th (6)	Sound imaging.
	11 th -14 th (8)	Radiation imaging.
	7 th	1 st Incourse Examination
	14 th	2 nd Incourse Examination

Recommended Readings:

- William R. Hendee, E. Russell Ritenour, Medical Imaging Physics, 4th Edition, 2002, Wiley-Liss, Inc., ISBN: 9780471382263.
- Geoff Dougherty, Digital Image Processing for Medical Applications, 1st Edition, Cambridge University Press, ISBN: 9780521860857.
- Thomas Martin Deserno, Biomedical Image Processing, Springer, ISBN: 9783642158162.
- [S. Ananthi](#), ATextbook of Medical Instruments, New Age International Pvt Ltd Publishers, ISBN:9788122415728.
- TinkuAcharya, Ajoy K. Ray, Image Processing: Principles and Applications, Wiley, 2005, ISBN: 9780471719984
- Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, 4th Edition, Pearson Education, ISBN: 9780133356724
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