Course Curriculum for B.Sc. (Honors)
Department of Applied Chemistry and Chemical Engineering (ACCE)
University of Dhaka, Dhaka-1000, Bangladesh.

B.Sc. (Honors) course curriculum in **Applied Chemistry and Chemical Engineering** under integrated course system from the session 2016-2017 and onward.

1. Graduation Criteria

1.1. Name of Degree: B.Sc. (Honors) in Applied Chemistry and Chemical Engineering.
1.2. Entrance qualification: H.S.C. (Science) with Chemistry, Physics and Mathematics.

The credit is defined as follows:

i. For theoretical courses, 14 class hours.
ii. For practical courses, 28-hour lab work = 1 credit.

1.3. Total Credits: A total of 163 credits of which will consist of 120 credits of theoretical courses; 28.5 credits of sessional; 10.5 credits of field work, in-plant training and project; and 4.0 credits for viva-voce. For graduation a student has to complete all the credits for the session s/he is registered.

1.4. Total Years: Honors degree shall be extended over a period of 4 academic years with 2 semesters per year (i.e. 4× 2 = 8 semesters). A student will be given 2(two) extra years in addition to 4 years to complete his/her degree; however, a student will be allowed to have readmission once in a year and total year of graduation (06 years) should not be exceeded. Each academic semester has a duration of 6 calendar months to be distributed as follows:

Class:	14 weeks, 3 class hours per week for each theoretical course, (1.5 hours per class)
Preparation Leave (PL):	02 weeks
Exam:	03 weeks
Results:	03 weeks
Total:	22 weeks per semester

1.5. Total Credits in 8 semesters (4 years): 163.0

1.6. Introduction and Course Identification:

The undergraduate students of different years of this department have to follow the course schedule given. The letter prefix in any course number indicates the department offering the courses or the discipline viz. ACCE for Applied Chemistry and Chemical Engineering, MAT for Mathematics, PHY for Physics.

Each course is designated by a three to four letter word identifying the department (details described earlier) which offers it followed by a four-digit number with the following criteria:

- ✓ The **first digit** corresponds to the **year** in which the course is taken by the student.
- ✓ The **second digit** represents the **semester** in which the course is taken by the student.
- ✓ The **third digit** is reserved for **departmental use** for such things as to identify different areas within a department.
- ✓ The **last digit** is for a theoretical course and for a laboratory or sessional course.

The minimum credits to be completed for obtaining the degree of B.Sc. (Honors) in Applied Chemistry and Chemical Engineering are 163.

Teaching of the courses:

- ✓ One-hour class per week is assigned for each number of credits of a theory course.
- ✓ Total Contact Hours in a semester for each 1.0 credit theory course: 14x1=14.
- ✓ For each 1.0 credit lab course, there will be 1 class per week of 2 hours' duration.
- ✓ Total Contact Hours in a semester for each 1.0 credit lab course: 14x2=28.

2. Examination System

A student will be evaluated continuously in the courses system, for theoretical classes s/he will be assessed by class attendance, in-course assessment and final examination. For laboratory courses, a student will be assessed by class attendance, observation of his performance at work, viva-voce during laboratory works, evaluation of laboratory reports and practical examination. Field work and In-plant training are evaluated based on submission of a report, by a written examination and viva-voce. Project work is evaluated on continuous assessment basis by respective guide and evaluation of project's report by the examiners.

2.1. Distribution of Marks: The marks of a given course will be as follows:

For a theory course:	
i. Class Attendance	05%
ii. Mid-Term	25%
iii. Final Examination	70%
Total Marks	100%
For a lab course:	
i. Lab Attendance	20%
ii. Performance and Reports	20%
iii. Final Examination	60%
For field work/ In-plant training:	
i. Report	40%
ii. Written Examination	40%
iii. Viva-Voce	20%
For project:	
i. Continuous Assessment	20%
ii. Report	80%

2.1.1. Class Attendance: The marks for class participation will be as follows:

Attendance	Marks
90% and above	5%
85% to 89%	4%
80% to 84%	3%
75% to 79%	2%
60% to 74%	1%
Less than 60%	0

A student will not be allowed to appear at the examination of a course if his/her class attendance in that course is less than 60%.

2.1.2. Final Examination: The final examination procedure will be as follows:

(a) Examination Committee: The examination committee will be formed consisting of 3 members from the same discipline and an external from outside for the final examination. The questions for the final examination will be prepared by the course teachers from the departments. The examination committee will moderate the questions for the final examination. The course teachers, who set the question will examine and mark the answer scripts separately. The two marks will be averaged by the tabulators. If the marks by the two examiners differ by more than 20% the concerned answer scripts will be examined by a third examiner recommended by the examination committee and the closest two marks among the three will be taken for average by the tabulators. All marks within a particular course domain will be added together to assign the final grade of that course.

(b) Duration of the Final Examination: For theoretical, field work, project and In-plant training courses of all sessions there should be a 1 (one) hour final examination for every course having 1 credit hour. Accordingly, final examination hour will proportionately vary with the course credit hours. For laboratory courses the time for the final examinations will be six (06) hours for each section.

3. Grading System

3.1. Letter Grade and Grade Point: Letter Grade and corresponding Grade-point will be awarded as follows:

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

3.2.1. GPA: Grade Point Average (GPA) is the weighted average of the points obtained in all the courses completed by a student in an academic year.

3.2.2. CGPA: Cumulative Grade Point Average (CGPA) will be calculated by the weighted average of previous CGPA and current GPA.

3.2.3. F Grades:A student having an F grade in course(s) has to retake the examination of the respective course up to twice with the immediately two following sessions only. Those who are having 'F' grade in any course s/he will not be eligible for the degree. However, the grade can be improved to B+ at best in applicable case.

3.2.4. Improvement:

i. If a student obtain a grade 'C+' or lower in a course in any year, he/she will be allowed to repeat the term final examination only once preferably with the following batch for the purpose of grade improvement but he/she will not be eligible to get a grade better than 'B+' in such a course. A student failing to improve his/her grade in a course can retain the earlier grade.
ii. Grade improvement will not be allowed in those courses in which a student obtains grade better than 'C+'.
iii. A student will be allowed to repeat a maximum of 20 credits in four years B.Sc. Program for grade improvement purpose. However, a student can be allowed to take maximum courses of 8.0 credits in a particular academic year for the stated purpose.
iv. There will be no improvement examination for practical, viva-voice, in-course and field work.

3.2.5. Readmission:

i. A student can take readmission 2 (two) times throughout the program either in the same class or in different classes. In both cases, he/she must complete the degree by 6 (six) years from the time of original admission.
ii. A student may seek readmission and continue studies as a regular student provided he/she has at least 30% attendance in the previous year.
iii. Grades earned earlier by a student in the case of readmission shall, in general, cease to exist and the student has to retake all courses and examinations, but in case if they do

not get the opportunity to repeat the course due to late admission, marks of in-course assessment and laboratory performance/ assessments in the previous year may be retained by the students.

3.2.6. Promotion to next academic year

To get promotion to the next academic year a student should obtain a minimum GPA 2.00 for 1st year to second year, and CGPA 2.25 for 2nd year to 3rd year and 2.50 for 3rd year to 4th year. However, for obtaining degree the CGPA of all academic years should be at least 2.50 having no 'F' grade in any course. A student will be promoted from 1st Semester to 2nd semester, 3rd semester to 4th semester, 5th semester to 6th semester and 7th semester to 8th semester automatically after appearing the semester final examination.

The semester-wise distribution of credits of different years is listed below:

Four Year Distribution:

Year	***Courses (Semester)***	
Year 1	***Semester I:*** *Theory = 5 courses* *Lab = 3* ***Total: 20.0 Credits***	***Semester II:*** *Theory = 5 courses* *Lab = 3* *Field Work* *Viva* ***Total: 20.0 Credits***
Year 2	***Semester I:*** *Theory = 6 courses* *Lab = 2* ***Total: 20.0 Credits***	***Semester II:*** *Theory = 5 courses* *Lab = 2* *Field Work* *Viva* ***Total: 21.0 Credits***
Year 3	***Semester I:*** *Theory = 6 courses* *Lab = 2* ***Total: 21.5 Credits***	***Semester II:*** *Theory = 5 courses* *Lab = 2* *Field Work* *Viva-Voce* ***Total: 20.5 Credits***
Year 4	***Semester I:*** *Theory = 5 courses* *Lab = 2* *Project/ In-Plant Training* ***Total: 21.0 Credits***	***Semester II:*** *Theory = 4 courses* *Lab = 2* *Project/ In-Plant Training* *Viva-Voce* ***Total: 19.0 Credits***
Grand Total 163.0 Credits		

Semester-wise List of Courses

First Year (Semester-I)		
Course Code	**Course Title**	**Credit**
ACCE1101	Chemical Technology-I	**3.0**
ACCE1102	Physical Chemistry-I	**3.0**
ACCE1103	Inorganic Chemistry-I	**3.0**
ACCE1104	Qualitative Inorganic Analysis Sessional	**1.5**
ACCE1105	Gravimetric Analysis Sessional	**1.5**
MAT 1101	Differential and Integral Calculus	**3.0**
PHY 1101	Properties of Matter, Optics and Modern Physics	**3.0**
PHY1102	Physics Sessional	**2.0**
Total Credits		**20.0**

First Year (Semester-II)		
Course Code	**Course Title**	**Credit**
ACCE 1201	Mass and Energy Balance	**3.0**
ACCE 1202	Chemical Engineering-I	**3.0**
ACCE 1203	Organic Chemistry-I	**3.0**
ACCE 1204	Qualitative Organic Analysis Sessional	**1.5**
ACCE 1205	Volumetric Analysis Sessional	**1.5**
ACCE 1206	Workshop Practice	**1.5**
ACCE 1207	Field Work	**1.5**
	Viva-Voce	**1.0**
MAT 1201	Linear Algebra and Coordinate Geometry	**2.0**
PHY 1201	Electricity and Magnetism	**2.0**
Total Credits		**20.0**

Second Year (Semester-I)		
Course Code	**Course Title**	**Credit**
ACCE 2101	Chemical Reaction Engineering	**3.0**
ACCE 2102	Chemical Technology-II	**3.0**
ACCE 2103	Physical Chemistry-II	**3.0**
ACCE 2104	Organic Chemistry-II	**3.0**
ACCE 2105	Organic Synthesis Sessional	**1.5**
ACCE 2106	Physical Chemistry Sessional	**1.5**
MAT 2101	Multivariable Calculus	**2.0**
PHY 2101	Fundamentals of Electrical Engineering	**3.0**
Total Credits		**20.0**

Second Year (Semester-II)		
Course Code	**Course Title**	**Credit**
ACCE 2201	Fluid Mechanics	**3.0**
ACCE 2202	Chemical Engineering-II	**3.0**
ACCE 2203	Inorganic Chemistry-II	**3.0**
ACCE 2204	Fundamentals of Computer Science and Engineering	**3.0**
ACCE 2205	Inorganic Preparations Sessional	**1.5**
ACCE 2206	Engineering Drawing Sessional	**2.0**
ACCE 2207	Field Work	**1.5**
	Viva-Voce	**1.0**
MAT 2201	Ordinary Differential Equations and Numerical Analysis	**3.0**
Total Credits		**21.0**

Third Year (Semester-I)		
Course Code	**Course Title**	**Credit**
ACCE 3101	Chemical Technology-III	**3.0**
ACCE 3102	Chemical Engineering-III	**3.0**
ACCE 3103	Fuel and Petrochemical Engineering	**3.0**
ACCE 3104	Analytical Chemistry and Material Testing	**3.0**
ACCE 3105	Electrochemical Engineering	**3.0**
ACCE 3106	Medicinal Chemistry	**3.0**
ACCE 3107	Industrial Raw Materials and Product Analysis	**2.0**
ACCE 3108	Instrumental Analysis	**1.5**
Total Credits		**21.5**

Third Year (Semester-II)		
Course Code	**Course Title**	**Credit**
ACCE 3201	Chemical Engineering-IV	**3.0**
ACCE 3202	Materials Science & Engineering	**3.0**
ACCE 3203	Corrosion Engineering	**3.0**
ACCE 3204	Metallurgy	**3.0**
ACCE 3205	Industrial Economics, Psychology & Management	**3.0**
ACCE 3206	Polymer Analysis Sessional	**1.5**
ACCE 3207	Chemical Engineering Sessional I	**1.5**
ACCE 3208	Field Work	**1.5**
	Viva-Voce	**1.0**
Total Credits		**20.5**

Fourth Year (Semester-I)		
Course Code	**Course Title**	**Credit**
ACCE 4101	Chemical Engineering-IV	**3.0**
ACCE 4102	Chemical Technology-IV	**3.0**
ACCE 4103	Polymer Science and Engineering	**3.0**
ACCE 4104	Spectroscopic Method of Analysis	**3.0**
ACCE 4105	Pharmaceutical Process & Technology	**3.0**
ACCE 4106	Chemical Engineering Sessional II	**1.5**
ACCE 4107	Fuel and Petrochemical Engineering Sessional	**1.5**
ACCE 4001/ ACCE 4002	Project/ In-plant Training	**3.0**
Total Credits		**21.0**

Fourth Year (Semester-II)		
Course Code	**Course Title**	**Credit**
ACCE 4201	Chemical Technology-V	**3.0**
ACCE 4202	Instrumental Analysis	**3.0**
ACCE 4203	Process Control	**3.0**
ACCE 4204	Environmental Chemistry and Engineering	**3.0**
ACCE 4205	Environmental Engineering Sessional	**1.5**
ACCE 4206	Computational Techniques in Chemical Engineering Sessional	**1.5**
ACCE 4001/ ACCE 4002	Project/ In-plant Training	**3.0**
	Viva-Voce	**1.0**
Total Credits		**19.0**
Grand Total		**163.0**

FIRST YEAR

Semester - I

ACCE 1101: Chemical Technology-I **Credit: 3.0**
3 Hours/Week

Description:

This course includes basic principles and importance of chemical technology. It also includes selected important topics of plant design and implementation of a chemical project. Plant design in accordance with feasibility study, plant site and used technology, piping and instrumentation are also comprised in this course. Under study of typical chemical technological plants, water treatment plant and ceramic industries are incorporated.

Objectives:

- To deepen the students' knowledge of the plant design and implementation of a chemical plant.
- To introduce students with different methods of carrying out a design project.
- To provide fundamental knowledge about feasibility study, storage and supply, health and safety aspects, maintenance of a chemical plant.
- To give elementary introduction about various methods to treat municipal and industrial water.
- To introduce student to the ceramic industries and methods of manufacture of different ceramic products.

Contents: **No. of Classes**

Introduction to Chemical Technology: Importance of chemical technology for industry and development of chemical technology. Basic principles of chemical technology and classification of chemical technological processes **02**

Design and Implementation of a Chemical Project: Methods of carrying out a design project. Process development. Design information from literature. Techno-economic feasibility study. Selection of plant site, technology, utility services, instrumentation, storage and supply systems, waste disposal, health and safety aspects, maintenance. Construction and operation of a chemical industry. Materials of construction: Metals, alloys, non-metals, inorganic materials and organic materials. **08**

Plant design & Project engineering: The design approach, design considerations, process design developments, optimum design, practical considerations in design. Definition and scope of project engineering, project evaluation. **04**

Study of Typical Chemical-Technological Plants: **14**

Water Conditioning and Water Treatment: Sources of water and water quality. Various physical and chemical methods of treatment. Municipal water supply and municipal water treatment processes. Boiler feed water (various quality parameters of water for boiler). Water for industrial uses and their treatment before feeding. Sewage treatment and disposal. Industrial water treatment processes (primary, secondary and tertiary).

Ceramic Industries: Basic raw materials. Chemistry related to ceramic industry. Classification of ceramic products. Methods of manufacture of different ceramic products including white wares, structural clay products; refractories, special ceramic products, ceramic composites, Ferro-electric and Ferro-magnetic ceramics and space age ceramics.

Learning Outcomes:

After completing this course the students will be able to:

- Explain the fundamentals of process plant design and complete conceptual or preliminary design.
- Demonstrate basic engineering design and construct an assessment of economic performance of the proposed plant.
- Recognize the common physical, chemical and biological unit operations encountered in water treatment processes.
- Discuss water quality data and characterize water and wastewater and illustrate the fundamentals of water and wastewater treatment.
- Classification of ceramic products and understand the basics of the properties of advanced ceramic materials
- Understand the basics of ceramic processing, and methods of manufacture of different ceramic products.

Reference Books:

- Peters, M.S., Timmerhaus, K.D., West, R.E., Timmerhaus, K. and West, R., 1968. Plant design and economics for chemical engineers (Vol. 4). New York: McGraw-Hill.
- McCabe, W.L., Smith, J.C. and Harriott, P., 1993. Unit operations of chemical engineering (Vol. 5, p. 154). New York: McGraw-Hill.
- Thuesen, H.G., Fabrycky, W.J. and Thuesen, G.J., 1977. Engineering economy. Englewood Cliffs, NJ: Prentice-Hall.
- Felder, R.M. and Rousseau, R.W., 1986. Elementary principles of chemical processes (p. 260). NY etc.: Wiley.

- Uppal, M. M. 1961. Textbook of Engineering Chemistry: For Engineering Students, Khanna.
- Shreve, R.N. and Brink Jr, J.A., 1977. Chemical Process Industries (No. 4th Edition). McGraw-Hill Book.

ACCE 1102: Physical Chemistry-I **Credit: 3.0**
3 Hours/Week

Description:

The aim of the module course, teach the students to define, explain and applications of the important terms and laws in physical chemistry science such as ideal gas, entropy, enthalpy, free energy, ideal solution, zero, first, second and third laws of thermodynamics and provides the sufficient knowledge about laws of gases and their application in life process.

Objectives:

- To introduce the students with behavior of ideal and real gas.
- To provide about kinetic theory of gases and various laws of ideal gases.
- To give fundamental ideas about the behavior of liquids, solids and solutions.
- To deepen their knowledge about chemical equilibrium.
- To broaden their knowledge about catalysis and reaction kinetics.
- To teach them the fundamentals of thermodynamics and thermochemistry.

Contents:	**No. of Classes**
Behavior of Ideal and Real Gases: Kinetic theory of gases. Equation of state for real gases. Joule-Thompson effect. Liquefaction of gases. Vander Waals equation and the critical state. Law of corresponding state. Vapor pressure. Trouton's law.	**03**
Liquids: Intermolecular forces in liquids (London Forces, Hydrogen Bonding). Vapor pressure and its determination, surface tension, capillary action, measurement of surface tension. Interfacial tension, surface tension and temperature, viscosity and fluidity, measurement of viscosity, viscosity and temperature. Refractive index (specific refraction, molar refraction), determination of refractive index, optical activity, specific rotation, measurement of optical activity.	**03**
Solids: Types of solids solid crystals, miller indices, crystal structure, classification of crystals on the basis of bonds, structure of metal crystal, crystal defects, liquid crystal. Band theory of solids, simple inorganic compounds	**02**

Solutions: Type of solutions, units of concentration, solution of gas in liquid, Henry's law. Solution of solid in liquid, solubility curve. Distribution law: its application.	**02**
Dilute Solutions: Theory of dilute solutions, ideal solution, Raoult's law, Colligative properties: (a) Lowering of vapor pressure, (b) Elevation of boiling point, (c) Depression of freezing point (d) Osmosis and osmotic pressure. Molecular weight from colligative properties, ideal and non-ideal solution	**03**
Chemical Equilibrium: Law of mass action, equilibrium constants of some typical reaction, Le-Chatelier and Braun's principle, degree of dissociation and equilibrium constant.	**03**
Acid/Base Equilibria: Theories of indicators, pH and pH measurements, buffer solution. Acid base titration, solubility product principle and its application, common ion effect.	**02**
Kinetics and Catalysis: Rate and rate expressions of simple reaction, order and molecularity. First, second, third, zero and fractional order reactions with examples, Methods of determination of the order of reactions. Theory of reaction rate. Types of catalysts, preparation and properties of catalyst, catalysis, retardation and poisoning, enzyme reactions.	**04**
Thermodynamics: Introduction, first law of thermodynamics, reversible and irreversible processes, isothermal and adiabatic changes. Second law of thermodynamics, Carnot theorem, Entropy and free energy. Gibbs-Helmholtz equation, Classius-Clapeyron equation, third law of thermodynamics.	**03**
Thermochemistry: Laws of thermochemistry. Hess's law, heat of reaction, heat of formation, heat of solution, heat of neutralization, heat of combustion and bond energies.	**03**

Learning Outcomes:

At the end of this course students will be able to-

- Explain the thermodynamics and systems in a proper way
- How work will be done in different process even at compression and expansion processes.
- Calculate heat of reactions and change of heat of solution.
- Understand change of entropy, enthalpy and free energy in different processes and systems.
- Can explain how factors affecting chemical equilibrium and change of solubility of gas and solid under the effect of pressure and temperature.
- Understand colligative properties and their applications in our life.

Reference Books:

- A Text Book of Physical Chemistry-S. Glasstone.
- Principles of Physical Chemistry-Bhal and Tuli
- An Introduction to Physical Chemistry, Haque and Molla
- Practical Physical Chemistry – Findlay
- Chemical Thermodynamics - Steiner.
- Thermodynamics for Chemistry - S. Glasstone.
- Phase Rule - A. Findlay (Revised by campbell)
- Introduction to Electrochemistry - S. Glasstone.
- Physical Chemistry – Borrow

ACCE 1103: Inorganic Chemistry-I **Credit: 3.0**
3 Hours/Week

Description:

This course highlights on the atomic structure, bonds and special characteristics of different elements of periodic table. This is a descriptive inorganic chemistry course. Concepts of bonding and related thermodynamics involved, acid and bases and oxidation-reduction mechanisms are also discussed.

Objectives:

This module aims to

- Provide basic concepts of the atomic structure, periodic properties.
- Help students give an in-depth knowledge in bonding models, inorganic thermodynamic, redox reactions, acids and bases, nuclear chemistry and common aspects of qualitative and quantitative analysis.

Contents:	**No. of Classes**
Electronic Structure of Atom: Bohr's atom model, wave nature of electrons, the photoelectric effect, quantum numbers, shapes of the atomic orbitals, effective nuclear charge, and energies of orbitals, Aufbau principle, Pauli's Exclusion Principle, Hund's rule, electron and ion electron configurations, magnetic properties of atoms.	**03**
Periodic Table: Periodic classification of elements and periodic properties.	**04**
Chemical Bonds: Electronic concept of chemical bonds, types of bonds. Elementary treatments of valence bond and molecular orbital theories, geometry of molecules,	**04**

hybridization, and bond order. Other types of chemical bonds, shapes of molecules on the basis of valance shell electron pair repulsion (VSEPR) theory.

Inorganic Thermodynamics and Energetic: Bond energy terms, enthalpy, entropy, and thermodynamics of the formation of ionic and covalent compounds. The driving force of a reaction, lattice energy, Born-Haber cycle, energy of hydration, energy change of the solution process, ionization energies, electronegativity, electron affinity. **04**

Oxidation and Reduction: Electronic concept, oxidation state and oxidation number. Writing of equations involving oxidation-reduction reactions, equivalent weights of oxidizing and reducing agents. **03**

Acids and Bases: Acid-base concepts, measuring of acid-base strength, hard and soft acids and bases. **03**

Nuclear Chemistry: Radioactivity, patterns of nuclear stability, nuclear transmutations, rates of radioactive decay, detection of radioactivity, energy changes in nuclear reactions, nuclear fission, nuclear fusion, isotopes, isobar, isomers, methods of separation of isotopes, applications of radioisotopes, biological effects of radiation. **03**

Aspects of Analysis: Common aspects of qualitative and quantitative analysis **04**

Learning Outcomes:

After successful completion of this course students will be able to-

- Predict physical and electronic properties of atoms using current models and theories in chemistry.
- Apply current chemistry models/theories to understand and predict the physical/electronic properties, bonding, and reactivity that occur in inorganic compounds.
- Construct qualitative sets of molecular orbital for simple molecules and inorganic complexes.
- Describe the physical and electronic properties of inorganic molecules.
- Able to correlate the thermodynamics and the energetic for the spontaneity of the inorganic processes.
- Develop the basic concepts of acids, bases and redox processes.
- Understanding basic concepts of radioactivity, radioisotopes and their applications.
- Using concepts and models applicable to inorganic chemistry, students will analyze inorganic systems in a systematic and detailed fashion.

- By completing this course student will understand the foundational principles and topics relevant to the field of inorganic chemistry. This will aid the program outcomes to prepare students for the assessment, employment or further educational training.
- As well as learning content, students will also develop (or further develop) important process skills which will enable lifelong learning (POGIL and Learning Model).

Reference Books:

- Advanced Inorganic Chemistry - Cotton & Wilkinson
- Modern Inorganic Chemistry - R. D. Madan
- Introduction to Modern Inorganic Chemistry - S. Z. Haider
- Advance Inorganic Chemistry S. Z. Haider
- Basic Inorganic Chemistry - Cotton & Wilkinson
- Nuclear & Radiochemistry - Friedlander & Kannedy.
- Chemistry- The Central Science- Theodore L. Brown; H. Eugene LeMay, Jr.; Bruce E. Bursten
- Descriptive Inorganic Chemistry- Geoff Rayner-Canham
- Introduction to Semimicro Qualitative Analysis- J. J. Lagowski and C. H. Sorum
- Textbook of Qualitative Inorganic Analysis- Arthur I. Vogel
- Textbook of Quantitative Inorganic Analysis- Arthur I. Vogel

ACCE1104: Qualitative Inorganic Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

Qualitative inorganic analysis is that branch or method of analytical chemistry which seeks to establish the elemental composition of inorganic compounds through various reagents. In other words, qualitative inorganic analysis is a method of analytical chemistry which seeks to find the elemental composition of inorganic compounds. It is mainly focused on detecting ions in an aqueous solution; therefore, materials in other forms may need to be brought to this state before using standard methods. The solution is then treated with various reagents to test for reactions characteristic of certain ions, which may cause change in color, precipitation and other visible changes.

Objectives:

- To provide hands-on experience in detecting, identifying, separating and conforming of the presence of metals.
- To acquire the knowledge required to identify and treatment of mixture of chemical species and their analysis.
- To internalize good laboratory practices.

Contents: **No. of Classes**

- General Lab techniques. **16**
- Techniques of detection, identification, separation and confirmation of presence of metals and non-metals, ions and (acidic and basic) radicals in inorganic salts, in mixture of salts by employing semi-micro methods.
- Treatment of mixtures with interfering substances, their removal and analysis.
- Treatment of insoluble substances.

Learning Outcomes:

After completing this course the students will be able to:

- Learn the standard laboratory techniques for analyzing inorganic substances.
- Distinguish the techniques of detection, identification, separation and confirmation of presence of metals and on-metals, ions and (acidic and basic) radicals in inorganic salts, in mixture of salts by employing semi-micro analysis.
- Familiarize themselves about the subject of inorganic qualitative analysis, including the equipment, reagents, and procedures that are going to be used in the laboratory.
- Know how to remove and analyze interfering substances in a mixture.
- Know the preliminary experiments including the classification of precipitates, handling precipitates, separation techniques, flame tests, brown ring test and solvent extraction.
- Keep written records of the experiments and display the observations in the form of day-to-day laboratory report.

Reference Books:

- Qualitative Inorganic Analysis – A.I. Vogel.
- Quantitative Inorganic Analysis – A.I.Vogel.
- Chemistry: Inorganic Qualitative Analysis in the Laboratory - Clyde Metz and Mary E. Castellion

ACCE 1105: Gravimetric Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

This is a laboratory course work provides an understanding of the principles of gravimetric analysis in chemistry. The determination of various chemical species (e.g. calcium, copper, zinc, sulfate, etc.) and their estimation through gravimetric method is very important in chemistry and chemical engineering alike. This course gives hands-on experience in determining chemical species present and teaches good laboratory practices. Report writing and in-lab problem solving is also included with the course.

Objectives:

To help students

- Understand the basic principles of gravimetric analysis
- Acquire the knowledge required to identify different chemical species through this analytical procedure
- Internalize good laboratory practices

Contents:	**No. of Classes**
Estimation of cations and anions e.g., iron, calcium, copper, zinc, sulfate, phosphate, chloride etc.	**16**

Learning Outcomes:

At the end of the course, learners will be able to:

- Perform basic analytical tests to identify cations and anions
- Develop a greater understanding of gravimetric analysis
- Analyze real life problems and be able to do sample preparation correctly

Reference Books:

- Mendham, J. (2006). Vogel textbook of quantitative chemical analysis. Pearson Education India.

MAT 1101: Differential and Integral Calculus **Credit: 3.0**
3 Hours/Week

Description:

This is an introductory course on differentiation and integration theory and applications. Differentiation and integration is fundamental in learning engineering. This course covers concept of integration and differentiation, functions and limits, determination of area under the curve and most importantly their applications.

Objectives:

This course aims to:

- Provide students in depth knowledge on the theories of differentiation and integration
- Help students acquire techniques of integration and differentiation
- Help students understand the relationship between integration and area under a curve/rate graph

- Enable the students in solving arc lengths, surface of revolutions and volumes of different objects

Contents: **No. of Classes**

Differential Calculus:

Functions: Functions and their graphs (polynomial and rational functions, logarithmic and exponential functions, trigonometric functions, hyperbolic functions and their inverses), combination of functions. **03**

Limits and Continuity: Basic limit theorems, limit at infinity and infinite limits, continuous functions, algebra of continuous functions, properties of continuous functions on compact intervals, Intermediate Value Theorem **04**

Differentiation: Tangent lines and rates of change, definition of derivative, one-sided derivatives, rules of differentiation, successive differentiation, Leibnitz theorem, related rates, linear approximations and differentials. L'Hospital's rules. **04**

Applications of the Derivative: Rolle's theorem, Mean value theorem, increasing and decreasing functions, concavity and points of inflection, extrema of functions, Optimization problems. **03**

Integral Calculus:

Integrals: Antiderivatives and indefinite integrals, Techniques of integration. **03**

Definite Integration using Anti-derivatives: definite integration using Riemann sums, fundamental theorem of calculus, basic properties of integration, integration by reduction **04**

Applications of Integration: Plane areas, solids of revolution, volumes by cylindrical shells, volumes by cross-sections, arc length and surface of revolution. **04**

Improper Integrals: Gamma and Beta functions (definition and examples only) **03**

Learning Outcomes:

After completing this course, the student will be able to:

- Understand and carry out integration and differentiation using formulae
- Apply the knowledge in solving problems
- Evaluate areas and volumes of different objects

- Apply integration to compute arc lengths, volumes of revolution and surface areas of revolution
- Evaluate certain indefinite forms

Reference Books:

- H. Anton et al, Calculus with Analytic Geometry.
- E. W. Swokowski, Calculus with Analytic Geometry.
- G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Addison Wesley; 9 editions (August 14, 1995).
- J. Stewart, Single Variable Calculus: Early Transcendental, Cengage Learning; 7 editions (2012).

PHY 1101: Properties of Matter, Optics and Modern Physics **Credit: 3.0**
3 Hours/Week

Description:

PHY 1101 covers the fundamental properties of matter, properties of light propagation and their interactions with matter and quantum, atomic and nuclear physics. This course introduces basic laws and equations to describe physical phenomena.

Objectives:

This course aims to

- Understand Newton's law of gravitation and its application
- Understand surface tension of liquid and its effects on liquid.
- Understand the viscosity of liquid and gaseous state of matter.
- Understand the problems related to streamline flow of liquid.
- Know about the different kinds of aberration in Geometrical Optics and matrix analysis of lenses
- Gather knowledge about interference with some applications of interference.
- Know the mechanism of diffraction and its applications.
- Understand the particle nature of electromagnetic wave and its applications
- Understand the wave nature of particle which can explain some physical phenomenon.
- Understand the atom model and its development
- Understand the wave function and to develop the Schrodinger’s equation which is satisfied by the wave function.
- Apply the Schrodinger’s equation for different problems.

Contents: **No. of Classes**

Properties of Matter: Gravitation Theory, Newton's Law, Gravitational Potential, Calculation of potential, Calculation of Potential and Force in Simple Cases, Escape Velocity. Planck Mass. Elementary Theory of Elasticity. Hooke's Law. Elastic Moduli, Relations between the Moduli, Bending of Beams Torsion. Surface Tension: Adhesive Force, Cohesive Force, Molecular Theory of Surface, Tension, Capillarity, Surface Tension of a Mercury Drop, Variation of Surface Tension with Temperature. Viscosity: Newton's Law of Streamline Flow. Poiseulle's Formula, Applications, Variation of Viscosity with Temperature. **09**

Optics: Aberration: Spherical Aberration, Chromatic Aberration, Astigmatism, Ray Matrices, Applications. Coherence: First Order Coherence, Spatial and Temporal Coherence, Higher Order Coherence. Interference of Waves: Principle of Superposition, Phase Velocity and Group Velocity: Huygens Principle, Young's Double Slit Experiment, Bi-prism, Newton's Rings, Michelson's Interferometer, Shapes and Positions of Fringes. Diffraction: Fraunhofer Diffraction, Single, Double and Multiple Slits Diffractions, Diffraction Grating Spectrometer, Angular Dispersion, Resolving Power. **10**

Modern Physics: Electromagnetic Waves, Photoelectric Effect, Quantum Theory of Light, X-ray and X-ray Diffraction, Compton Effect. De Broglie Waves, Particle Diffraction, Uncertainty Principle. Rutherford Model of the Atom, Electron, Orbits, Atomic Spectra, the Bohr Atom, Energy Levels and Spectra, Atomic Excitation. Introduction to Wave Function and Wave Equation, Time Dependent Schrodinger's Equation, Expectation Values, Steady state Schrodinger's Equation, Linearity and Superposition, Operators, Particle in a box, Reflection and Transmission by a barrier, Tunnel Effect, Harmonic Oscillator. **09**

Learning Outcomes:

Students will be able to

- Apply the Newton's law of gravitation to study the gravitational field and potential and, also learn about the escape velocity and Kepler's planetary laws of motion.
- Understand the origin of surface tension and the role of surface tension in forming the different types of liquid surface.
- Learn to calculate the surface tension of water by capillary rise method and the surface tension of mercury by sessile drop method.
- Learn to calculate the coefficient of viscosity of liquid for streamline flow using Poiseulle's formula.
- Understand the difference between streamline flow and turbulent flow and the physical significance of Reynold's number.

- Learn the main cause of aberration in lenses and also matrix method used in matrix geometry of lens.
- Learn how different types of aberrations are produced and different mechanisms of minimizing aberrations.
- Learn conditions for interference with special emphasis on temporal and Spatial coherence.
- Learn how interference was examined by Thomas Young and conditions for occurring dark and bright fringes of interference pattern depending on the path difference between two coherent rays.
- Learn different types of applications of interference phenomena.
- Learn the definition, conditions and types of diffraction. Students specially get familiar with the single slit, double slit and multiple slit diffraction phenomena; especially diffraction Grafting and its use by a spectrometer and made clear to the students.
- Learn how Einstein's quantum theory of light can explain the experimental result of photoelectric effect.
- Learn how Davisson-Germer experiment can explain the experimental result of photoelectric effect.
- Learn the development and failure of Rutherford atom model and also learn elegant Bohr atom model.
- Learn the success of Bohr atom model in explaining the different energy levels of electron in an atom and in explaining energy spectral series.
- Learn the physical significance of wave function and its importance in developing Schrodinger's equation.
- Learn the application of Schrodinger's equation in solving quantum mechanical potential barrier problems.
  Learn the application of Schrodinger's equation to calculate the discrete energy eigen values of linear oscillator.

Reference Books:

- Optics; E. Hecht and A. Zajac; Addison-Wesley
- Optics by Rossi.
- Modern Optics by Guenther.
- Fundamentals of Optics; F. A. Jenkins and H. E. White. McGraw-Hill, Singapore.
- Vibrations and Waves A. P. French, Nelson, London.
- Principles of Optics; M. Born and E. Wolf, Pergamon Press.
- Physics: R. Resnick and D. Halliday (Wiley Eastern, New Delhi). Bangla translation published by the Bangla Academy is also available.
- The General Properties of Matter: F. W. Newman and V. H. L. Searle. , Edward Arrold Publishers, London.
- Properties of Matter: S. Ahmed and A. K. Nath

- A perspective of Modern Physics-A Beiser.
- Introduction to Quantum Mechanics-David J. Griffith.
- Quantum Mechanics-John L. Powell and Bernd Crasemann.
- Modern Physics for degree students-J.B. Rajam.
- Modern Quantum Mechamics-J.J. Sakurai.

PHY 1102: Physics Sessional **Credit: 2.0**
4 Hours/Week

Description:

This is a practical course covering the verification, determination and measurement of laws and fundamental properties in physics. This course offers students a better understanding of the theoretical topics.

Objectives:

The course aims to:

- Develop abilities and skills in doing practical experiments
- Provide studies of experimental and practical work
- Help students understand the theories and principles in physics better
- Stimulate interest for the subject.

Contents: **No. of Classes**

- Determination of the value of the acceleration due to gravity (g) using compound pendulum. **16**
- Determination of the spring constant and effective mass of a given spiral spring and hence to calculate the rigidity modulus of the material of the spring.
- Determination of Young's Modulus and Modulus of Rigidity of the material of a wire by (Searle's) dynamic method.
- Determination of surface tension of water at room temperature by capillary tube method.
- Determination of surface tension of mercury by Quincke's method.
- Variation of viscosity of water with temperature.
- Determination of the specific heat of a solid by the method of mixture with radiation correction.
- Determination of the specific heat of a liquid by the method of cooling.
- Verification of the laws of transverse vibration of a string. n-1, 1-T curves.

Learning Outcomes:

Student will be able to

- Identify and describe scientific phenomena, facts and laws, their concepts and theories in physics
- Translate data from the experiments to useful information
- Determine several parameters/ properties practically
- Apply knowledge and principles to tackle new situations.

Reference Books:

- Physics: R. Resnick and D. Halliday (Wiley Eastern, New Delhi).
- Practical Physics – Dr. Giasuddin Ahmed and Md. Shahabuddin

Semester –II

ACCE 1201: Mass and Energy Balance **Credit: 3.0**
3 Hours/Week

Description:

This course covers the basic chemical engineering concepts of units, material and energy balance of any process. Material balancing includes process classification, types of balances, material balance of chemical processes with or without chemical reactions, recycling, purging, bypassing, etc. In addition, application of material balance in unit operations are also covered. In energy balance portion, procedure for calculating enthalpy change, heat balance, heat capacity is discussed along with solving related mathematical problems. Stoichiometry, limiting and excess reactants, classification of fuels are also included in the course.

Objectives:

To help students-

- Implement unit conversions
- Perform material balances on different engineering processes
- Perform energy balances using differential equations and charts
- Enable to read thermos-physical data and properties from tables and charts

Contents:	**No. of Classes**
Basic Concepts: Principles of chemical engineering calculations, systems of units, process variables, basis of calculation.	**02**

Fundamental of Material Balance: Process classification; types of balances, principle and procedure of material balance. Typical flow sheet, batch, stage wise and continuous operation. Material balance with and without chemical reaction; bypass, recycle and purge operations with and without reactions. Basic material balance principles in unit operations such as evaporation, crystallization, drying, absorption, distillation. **08**

Stoichiometry: Definition, stoichiometric co-efficient, stoichiometric ratio, stoichiometric proportion, limiting and excess reactant, conversion etc. Stoichiometric calculations in metallurgical and electrochemical reactions. Stoichiometric calculations on fuels and combustion. Classification of fuels. Calorific value of fuels. Theoretical and excess air for combustion. Calculations on solid, liquid and gaseous fuels. **08**

Energy Balances: Trouton's rule, Kistyakowsky equation for non-polar liquids, estimation of heat capacity, calculation of enthalpy changes with and without phase change, estimation of latent heat of vaporization, heat balance calculations in processes without chemical reaction, effect of temperature on heat of reaction, enthalpy change for mixtures, enthalpy-concentration charts and applications. Kirchhoff's equation. Adiabatic and non-adiabatic reactions. Calculation of heat of reaction of industrial reactions. Energy balance calculations without and with chemical processes. **08**

Calculations of Balances for Industries: Combined material and energy balance calculations and industrial problems **02**

Learning Outcomes:

At the end of the course, learners will be able to:

- Perform correct unit conversion
- Perform material and energy balances for processes with and without chemical reaction
- Draw process flow diagrams
- Understand and Analyze degree of freedom of a process
- Use equations and relevant charts and tables to estimate enthalpies and perform energy balance
- Formulate combined energy and material balances to solve industry related problems.

Reference Books:

- K. V. Narayanan & B. Lakshmikutty, Stoichiometry and Process Calculations, Prentice Hall of India.
- Hougen A, Watson K. M, Ragatz R. A, Chemical Process Principles, John Wiley.
- David M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall.

- Richard M. Felder & Ronald W. Rousseau, Elementary Principles of Chemical Processes, Wiley India.
- B. I. Bhatt, and S. M. Vora, Stoichiometry (Third Ed), Tata McGraw Hill.
- Williams E. T, Johnson R. C, Stoichiometry for Chemical Engineers, McGraw Hill.
- Rao D. P, Murthy D. V. S, Stoichiometry for Chemical Engineers, McMillan.

ACCE 1202: Chemical Engineering-I **Credit: 3.0**
3 Hours/Week

Description:

This course includes selected important topics of unit operations, mass transfer and industrial safety. The unit operations part consists of different particle technology terminology, size reduction equipment and methods, solid handling techniques, agitation and mixing of solids and liquids. Basic ideas of humidification and dehumidification operations and design of cooling towers are included in mass transfer part. Preliminary concepts on industrial safety, fire and explosions, hazard identification and assessment are incorporated in safety part.

Objectives:

- To deepen the students' knowledge of the unit operations with a focus on size reduction, solid handling, mixing and agitation.
- To introduce students with different types of techniques and equipment those are used in unit operations.
- To provide fundamental knowledge about humidification and dehumidification operations, humidity charts and humidifiers design.
- To give elementary introduction about working principle, design and applications of cooling towers.
- To introduce student to the study of workplace occupational health and safety and different risk assessment and hazard mitigation techniques.

Contents: **No. of Classes**

Basic Concepts: Introduction to unit processes and operations and their symbols, process flow sheet, dimensions and units, basic chemical calculations including mole, equivalent weights, solids, liquids. Chemical engineering: definition, origin, growth and role in chemical process industries. Professional ethics of a successful chemical engineer and intimate connections with other engineering and sciences stream. **04**

Size Reduction: Particle size and shape, mixtures of particles. Size reduction equipment: Primary crushers, secondary crushers, intermediate & fine grinders, Ultra-fine grinders, cutting machines, open circuit & closed circuit grinding. Industrial screening equipment: **05**

Standard screen series, screen analysis, determination of particle size. Screen effectiveness and capacity. Crushing efficiency, energy requirements

Humidification & Dehumidification Processes: Introduction to humidification and dehumidification operations, characteristics of saturated and unsaturated vapor gas mixtures. Dry and wet bulb thermometry, humidity chart, adiabatic saturation temperatures, psychometric ratio, gas liquid contact. Design of humidifiers. Dehumidification operation. Principle and design of cooling towers (natural draft, forced draft and induced draft cooling towers). **05**

Agitation and Mixing: Agitation of low viscosity particle suspensions: axial flow impellers, radial flow impellers, close clearance stirrer, unbaffled tanks, baffled tanks, basic idea for designing agitators. Power number, Froude number, power consumption in agitation. Mixing of Solids: Types of mixers, various mixers for cohesive solids, power requirements, mixing index, axial mixing. Mixers for free flowing solids: ribbon blenders, screw mixers, tumbling mixers import wheels, mixing index in blending granular solids, mixing index at zero time, rate of mixing. **05**

Handling and Transport of Solids: Storage of solids, characteristics of bulk solids. Conveyors: Working principles, construction, advantages, disadvantages and design calculation of screw conveyors, belt conveyors, bucket elevators, pneumatic conveyors. Industrial trucks. Automated guided vehicles. Monorails and other rail guided vehicles. Cranes and hoists. **05**

Industrial Safety: Government regulations, identification and evaluation and control of various exposures in chemical industry. Fires and explosions: fire triangle, flammability characteristics of liquids and vapors. Design to prevent fires and explosions. Hazard identification and risk assessment. Accident investigations and case histories **04**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Characterize bulk solids and design storage bins and conveying systems.
- Design, working principle of different size reduction equipment.
- Select appropriate mixing and agitation techniques and equipment for specific solids and liquids.
- Use of humidity chart and calculation from psychometric chart.
- Identify hazards in industry that pose a danger or threat to their safety or health, or that of others.
- Control unsafe or unhealthy hazards and propose methods to eliminate the hazard.

Reference Books:

- McCabe, W.L., Smith, J.C. and Harriott, P., 1985. Unit operations of chemical engineering (Vol. 4). New York: McGraw-Hill.
- Coulson, J. M., Richardson, J. F., Sinnott, R. K., Backhurst, J. R. & Harker, J. H. 1999. Coulson & Richardson's Chemical Engineering, Butterworth-Heinemann.
- Badger, W. L. & Banchero, J. T. 1955. Introduction to chemical engineering, McGraw-Hill.
- ANDERSEN, L. B. & WENZEL, L. A. 1961. Introduction to Chemical Engineering, McGraw.
- Thompson, E. V., Ceckler, W. H. "Introduction to Chemical Engineering", McGraw-Hill Book Company Ltd. (1977).
- Peters, M. "Elementary Chemical Engineering", McGraw-Hill Book Company.
- Ghosal, S. K., Sanyal, S. K. and Datta, S. "Introduction to Chemical Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi (1997).
- Basic Principles of Chem. Engg. By Felder &Rousseau, 3rd Edition, Prentice Hall (2002).

ACCE-1203; Organic Chemistry-I **Credit: 3.0**
3 Hours/Week

Description:

This course provides a systematic study of the theories, principles, and techniques of organic chemistry. This course is designed to provide students with the opportunity to learn fundamental of organic chemistry including structures, bonding, reactions, functional groups, hybridization and isomerism. This course also deals with nomenclature, physical properties, synthesis and reaction of aliphatic, heterocyclic and aromatic compounds, alkyl halides, alcohols, ethers, aldehydes, ketones, carboxylic acids and derivatives, amino acids, proteins and amines.

Objectives:

This unit aims to

- Provide the theories of elements of organic chemistry including molecular structures, bonding, resonance, acid-base interaction etc.
- Learn different types of isomerism.
- Expose to the technique of naming organic compounds according to IUPAC and trivial methods.
- Provide the basic understanding of physical and chemical properties and preparation of different organic compounds including hydrocarbons, alkyl halides, amines, amides, alcohols, carboxylic acids and derivatives, aldehyde and ketone, heterocyclic compounds.
- Provide some insights into industrial synthetic routes for different organic compounds and their industrial applications.

- Provide fundamental ideas on the structure and properties of organic molecules of biological significance (i.e. proteins, nucleic acids and lipids).

Contents: **No. of Classes**

Hydrocarbons: Classification of hydrocarbons on the basis of hybridization, molecular orbital theory, geometry, bond angle etc. Isomerization and general reactions of alkanes (different substitution reactions, halogenation, cracking), alkenes (electrophilic addition, nucleophilic conjugate addition, oxidation, epoxidation/ring opening, ozonolysis, hydroboration, polymerization), stability of alkenes (Sytzeff rule), Markovnikov and anti-Markovnikov rule as applied to the electrophilic addition to unsymmetrical alkenes and alkynes (acidic properties, conversion to EVsZ-alkenes). Uses of hydrocarbons. **05**

Alkyl and Aryl Halides: Structure, preparation, manufacture and uses. Comparison of the C-X bond strength of alkyl and aryl halides, comparison of substitution reaction of alkyl halides and aryl halides, synthesis of alkyl and aryl halides, reaction of alkyl halides with alkali in different conditions, Wurtz reaction, organometallic compounds with special attention to the preparation, properties and uses of Grignard reagents and other organometallic compounds, safety and conditions for the synthesis of organometallic compounds. **04**

Alcohols and Phenols: Structure, preparation, manufacture, physical properties and uses. Differentiation of 1˚, 2˚, 3˚ alcohols, test for the presence of -OH group, reactions of alcohol and phenol including enolate alkylation, reaction of enolate with aldehyde and ketone (aldol reaction), conjugate addition of enolate **04**

Carbonyl Compounds: Fundamentals of carbonyl and carboxyl chemistry, nature of carbonyl reactivity, explanation of the reactivity of different carbonyl compounds, preparation, manufacture, and uses of carbonyl compounds. Reactions of aldehyde and ketones (nucleophilic and conjugate addition, nucleophilic substitution) and carboxylic acid and its derivatives (acid halide, anhydride, amide), keto-enol tautomerism. **05**

Aliphatic and Aromatic Amines: Structure, preparation, basicity with reference to pKa values and other properties, uses. Quaternary amines. Diazotization of aromatic amines and their coupling to obtain diazo compounds (dyes). **03**

Cyclic and Heterocyclic Compounds: Structure of fused bicyclic and Spiro cyclic compounds, effect of ring size on the stability of cyclic compounds, Bayer-strain theory. Preparation, manufacture, properties and uses of pyridine, Pyrrole, furan, and thiophene. Synthesis of quinoline derivative. **04**

Biomolecules: Structure of amino acids, peptides and proteins, color test for proteins. Structure of nucleic acid, DNA, DNA-replication and transcription. Structures of alkaloids, lipids, terpenes and steroids. **03**

Learning Outcomes:

Upon successful completion of this course the students will be able to

- Draw the structure of organic molecules and identify the functional groups.
- Name different unknown organic compounds according to IUPAC method.
- Explain the physical and chemical properties and preparation of different organic compounds including hydrocarbons, alkyl halides, amines, amides, alcohols, carboxylic acids and derivatives, aldehyde and ketone, heterocyclic compounds.
- Compare organic compounds (aliphatic/aromatic/carbonyl/amine) based on the physical and chemical properties.
- Gather knowledge about laboratory as well as industrial synthetic methods of different organic compounds.
- Explain the structure, properties, sources and application of specific organic molecules of biological interests.

Reference Books:

- Organic Chemistry: Clayden, Greeves, Warren and Wothers, Oxford University Press, 2001, NY.
- Organic Chemistry: Robert T. Morrison, Robert N. Boyd, Prentice Hall of India, 5th Ed. 1990, New Delhi.
- Organic Chemistry, Vol.-II: I. L. Finar, Longman, Low Price Ed.
- A Guide Book to Mechanism in Organic Chemistry,: Peter Sykes, Longman, 6th Ed. 1986.
- Biochemistry: Albert Lehlinger.

ACCE 1204: Qualitative Organic Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

The analysis and identification of unknown organic compounds constitutes a very important aspect of experimental organic chemistry. Qualitative organic analysis deals with the identification of elements or grouping of elements present in a sample. It provides insights into the problem or helps to develop ideas or hypotheses for potential research. The techniques employed in qualitative analysis vary in complexity, depending on the nature of the sample.

Objectives:

- To understand the purpose of doing qualitative organic analysis.
- To identify the functional groups in a given organic compound.
- To identify the melting point of a given organic compound.
- To identify unknown organic compounds.

Contents:	**No. of Classes**
• Preparation of different reagents used in qualitative organic analysis. • Detection and identification of elements other than carbon in organic compounds. • Identification of different types of organic compounds (solids and liquids) by solubility test, fusion test and group analyses, confirmation test, melting point and mixed melting point: halogen compounds, Sulphur compounds, nitrogen compounds, phenols, ethers, carbonyl compounds (aldehydes, ketones, carboxylic acids and other derivatives), amino compounds and phosphorus compounds.	**16**

Learning Outcomes:

Qualitative organic analysis is used to identify the identity of unknown organic compounds. The goal of qualitative organic analysis is to characterize the structures of organic compounds. Before the invention of modern instrumentation such as spectroscopy, qualitative organic tests were used to determine if functional groups were present in molecules. So, the main learning outcomes are –

- Students will demonstrate an ability to perform qualitative organic analysis of an unknown organic substance and to communicate the results of their analysis in oral fashion.
- Students will conduct basic manual qualitative analysis accurately using prescribed laboratory procedures.
- Students will demonstrate an ability to work together to collect and analyze data in order to answer specific questions pertaining to a typical organic reaction.

Reference Books

- Qualitative Organic Analysis- A.I. Vogel
- Organic Identification - Clarke.
- A Text Book of Practical Organic Chemistry – A.I. Vogel

ACCE 1205: Volumetric Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

This is a practical course that involves the determination of volume of reactants at the preliminary level needed for the ultimate result. This course offers verities of experiment starting from simple titration to complex one; quality measurement of vinegar, metal atom identification from its respective oxide etc.

Objectives:

- Prepare solution of any measurable concentration
- Determine the concentration of any reactant involved in acid-base or redox titration
- Measure the amount of core ingredient present in the commercial vinegar
- Find out the name of unknown di carboxylic acid.
- To devise feasible routes for the successful measurement of the unknown concentration.

Contents: **No. of Classes**

Titrimetric analysis of acid-base, redox, complex metric etc. Analysis of typical ores, minerals and alloys. **16**

Learning Outcomes:

The learning outcomes of the course are that the student

- Demonstrates the ability to perform various types of titration thus identifying the concentration of the desired element
- Apply various techniques to measure the quantity of the element.

Reference Books:

- Practical Volumetric Analysis by Peter McPherson
- Vogel's Quantitative Chemical Analysis by R.C. Denney, M.J.K Thomas & David J. Barne, J. Mendham.

ACCE 1206: Workshop Practice Sessional **Credit: 1.5**
3 Hours/Week

Description

This is a practical oriented course in which students are introduced to the use of different engineering materials, tools, equipment and processes that are common in engineering fields. Students are taught how to make common carpentering joints, measure instruments, cut metal

sheets, annealing, filing, boring, use gaskets, mechanical seal, oil, grease etc. Different welding processes like arc welding, gas welding and spot welding etc., heat treatment, molding, casting, machine shop processes, such as turning, knurling (drilling, thread cutting) etc., are also be carried out. Finally, students are given materials and task to manufacture simple items like nuts, bolts, pipe fittings etc.

Objectives:

The objective of this course is to teach students about management of workshop including inventory of materials and safety, the most common equipment in a workshop and their operation. This course will enable students

- To obtain basic working knowledge required for the production of various engineering materials.
- To practice workshop management and maintenance.
- To familiarize with workshop machinery and equipment like drills, lathes, welding torches, files, saws, hammers, etc.
- To practice plumbing, carpentering, welding,heat treatment, molding and casting.
- To learn about safety measures needed in a workshop and how to deal with accidents at work.

Contents:	**No. of Classes**
Carpentry: Use of carpenter's tools, common carpentering joints, work bench, Use of measuring instruments.	**16**
Plumbing: Pipe and pipe fittings (elbow, bend, tee, cross, reducer, Y, plug bush, running nipple), gaskets, mechanical seal, oil, grease.	
Familiarizing the students with the following processes: Welding (arc welding, gas welding and spot welding), heat treatment, molding and casting. Simple machine shop processes, such as turning, knurling (drilling, thread cutting).	

Learning Outcomes:

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

- Explain and strictly adhere to the rules and safety regulations for work in the mechanical workshop prevent and avoid accidents.
- Identify and use marking out tools, hand tools, measuring equipment etc.
- Select the appropriate tools required for specific operation.
- Make carpentering joints and pipe fittings.
- Perform metal joining operations by arc welding, gas welding and soldering

- Identify and produce different types of joints using rivets and screws and produce internal and external thread forms
- Perform a range of operations on Workshop Machinery E.g. Drills, Lathes.

Reference Books

- Kannaiah, P., & Narayana, K. L. (1999). Manual on Workshop Practice.
- S k Hajra Choudhry, A K Hajra choudry, "Elements of Workshop Technology".

ACCE 1207: Field Work **Credit: 1.5**

Description:

Industrial field work refers to work experience done during the program of study that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course student will visit at least two industries at the end of their second semester. For the students of first year generally the field work session continued for one day by visiting any public or private industry based on the availability.

Objectives:

The fundamental objective of the field work is to prepare students for future employment in their chosen industrial discipline. Field work enhances the academic material studied in 1st year by allowing students to practice what they have learned and to develop key professional attributes by experiencing the theoretical knowledge into practical perspective. Field work should provide an opportunity for students to:

- Correlate the theoretical knowledge with practically observed chemical industry.
- Experience the discipline of working in a professional industry.
- Develop understanding of the functioning and organization of a chemical process industry.
- Interact with other professional and non-professional groups within the industry.
- Apply engineering methods such as design and problem solving.
- Develop technical, interpersonal and communication skills, both oral and written.

Learning Outcomes:

This course will offer a student to achieve ability to-

- Demonstrate the use of the product and the function of many types of equipment involved.
- Analyze a given engineering problem, identifies an appropriate problem solving methodology, implement the methodology and propose a meaningful solution.

- Apply prior acquired knowledge in theoretical problem solving session.
- Identify sources of hazards, and assess/identify appropriate health & safety measures.
- Work in a team.
- Take initiatives.
- Effectively communicate solution to problems (oral, visual, written).
- Manage a project within a given time frame.
- Adopt a factual approach to decision making.
- Take engineering decision.

Viva-Voce **Credit: 1.0**

At the end of the year (after completing the course work of all the semester) a student will sit for an oral examination. Members of the examination committee will evaluate the students by asking questions relevant to the courses of the current year. The teacher panel interviews the students on subjects studied year-long and measure their competency and understanding.

MAT 1201: Linear Algebra and Co-ordination Geometry **Credit: 2.0**
2 Hours/Week

Description:

This course has been designed as an introduction to linear algebra and co-ordinate geometry. The topics of vector geometry and linear algebra have wide applications in other fields of mathematics, engineering, and computer science and business mathematics. It will broaden students' understanding of linear algebra, coordinates, vectors and matrices.

Objectives:

This course aims to

- Provide understanding of linear equations, help students recognize a system of linear equations and different approaches to solve them
- Provide understanding on how to set and solve problems
- Help students acquire a deep understanding of matrices, vector spaces and co-ordinate geometry

Contents: **No. of Classes**

Matrices and Determinants: Notion of matrix, Types of matrices, Matrix operations, Laws of matrix Algebra, Determinant, and its Properties, Minors, Cofactors, Elementary Row Operations and Row-Reduced Echelon Matrices. **05**

System of Linear Equations: System of linear equations (homogeneous and nonhomogeneous) and their solutions, Application of matrices and determinants for solving system of linear equations. **05**

Vector Spaces: Review of geometric vectors in R2 and R3 space. Vector space, Subspace, Linear independence of vectors; basis and dimension of vector spaces. Row and column space of a matrix; rank of matrices. Solution spaces of systems of linear equation. **05**

Linear Transformations: Kernel and image of a linear transformation and their properties, Matrix representation of linear transformations, Change of bases. **04**

Eigenvalues and Eigenvectors: Diagonalization. Cayley-Hamilton theorem, Applications. **03**

Co-ordinate Geometry: Changes of axes, Transformation of co-ordinates, Reduction of second degree equations to standard forms. Identifications of conics. Direction cosines and direction ratios. **06**

Learning Outcomes:

Students should be able to

- Perform matrix calculations and vector calculations
- Solve different linear algebraic problems with different strategies and approaches
- Perform logical thinking and analyzing which will enable them to solve problems using linear algebra and view problems in geometric ways.

Reference Books:

- H. Anton, and C. Rorres, Linear Algebra with Applications, 9th Edition,
- S. Lipschutz, Linear Algebra, Schaum's Outline Series.
- David C. Lay, Linear Algebra and Its Applications, 4th ed
- A.F.M. Abdur Rahman& P.K. Bhattacharjee, Analytic Geometry and Vector Analysis.

PHY 1201: Electricity and Magnetism **Credit: 2.0**
2 Hours/ Week

Description:

Electromagnetism has found a broad area of application with the advancement of our technologies. This course is designed to provide students with the working knowledge of elementary principles of electricity and magnetism in physics The class introduces laws of physics such as Coulomb's

law, Ohm's law, along with properties of electrical equipment such as diodes, capacitance, transformers and rectifiers.

Objectives:

- Develop understanding the concepts in electricity and magnetism
- Reinforce conceptual understanding through the use of problem solving skills

Contents:	**No. of Classes**
Electrostatics: Point Charges, Coulomb's Law, Electric Field Strength and Potential, Gauss's Law for Electrostatics, Electric Dipole, Density of Charge in a Polarized Dielectric, Gauss's Law for charges in a Dielectric, Capacitance Co-efficient of Potential, Capacitance and Induction Energy of Charged Systems. Electrical Images.	**05**
Direct Current: Current and Electromotive Force, Ohm's Law. Combination of Resistances and Kirchhoff's Laws, Wheatstone Bridge.	**04**
Magneto statics: Gauss's Law for Magnetism, Magnetic Dipole, Energy in a Magnetic Field.	**04**
Magnetic Quantities and Variables: Flux, permeability and reluctance, magnetic field strength, magnetic potential, flux density, Laws in magnetic circuits: Ohm's law and Ampere's circuital law. Series, parallel and series-parallel magnetic circuits. Ampere's law, Biot-Savat Law, Magnetic Fields of Simple Circuits, Galvanometers, Lorents Force, Cathode Ray Tube (CRT). Electromagnetic Induction: Faraday's Law of Induction, Lenze's Law, Self-Inductance, Mutual Inductance, Transformer. Magnetic Properties of Materials, Magnetization, B-H Curve, Hysteresis.	**06**
Thermo-electricity: Seebeck, Peltier and Thomson Effects, Thermocouple	**04**
Semiconductors and Rectification: Energy Bands (Qualitative), Holes, Intrinsic and Extrinsic Semiconductors, P-N. Junction, Depletion Layer, Forward and Reverse Biases, I-V curve, Diode Equation and Characteristics, Half-wave and Full-wave Rectification	**05**

Learning Outcomes:

Students will be able to

- Acquire a comprehensive understanding of the concepts, theories and perspective principlesinvolving electricity and magnetism.
- Apply these concepts to practical situations
- Understand the working principle of transformer, capacitance, thermocouple and semiconductors.

Reference Books:

- Physics, R. Resnick and D. Halliday; Wiley Eastern, New Delhi.
- Principles of Electricity; L. Page and N. L. Adams, D. Van Nostrand Company. N.J.
- Electricity and Magnetism: S. G. Starling; Longman Green and Co. London.
- Electromagnetic Fields and Waves: Paul Lorrain and Dale Corson, D. B. Taraporevala Sons and Co., Bombay.
- Foundations of Electromagnetic Theory: John R. Reitz, F. J Milford and R. W. Christy. Addison Wesley, Mass, U.S.A.
- Bidyat O Chumbak, A. M. Harunar Rashid; Techno Mission, Gulshan, Dhaka.
- Concepts of Electricity and Magnetism, M. S. Huq- A. K. Rafiqullah and A. K. Roy, Students' Publications, Dhaka.

SECOND YEAR

Semester - I

ACCE 2101:Chemical Reaction Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course on Chemical Reaction Engineering applies the concepts of reaction rate, stoichiometry and equilibrium to the analysis of different chemical reacting systems, principles of chemical kinetics, and reactor analysis and design. It also includes different types of thermodynamic properties, feasibility and spontaneity of these systems. Different methods and techniques like differential, integral, least square methods are also included to solve the systems.

Objectives:

- To develop general procedures for analysis and design of a variety of chemical reaction systems for which engineering of reactions is needed.
- To introduce the students with basic concepts of chemical kinetics and chemical reactor design.
- To provide basic knowledge to students about different types of reactions and their rate expression development methods.
- To familiarize the students with different catalytic reactions, their applications and catalysts characterization.
- To give primary knowledge of thermodynamic properties, feasibility of reactions, application to industrial problems.

Contents:	No. of Classes
Basic Concepts on Chemical Kinetics: Elementary and non-elementary reactions, kinetic model for non-elementary reactions, testing kinetic models and searching for a mechanism. Reversible and irreversible single reactions, chain reactions, series, parallel and series-parallel reactions, enzymatic reactions. Rate of chemical reaction, three-point differentiation formulas to estimate the rate, theory of reaction rates, effect of temperature on reaction rate. Collision and activated complex theories, Arrhenius equation. Interpretation of batch reactor data for simple and complex reactions. Multiple reactions: yield and selectivity Catalytic and Non-catalytic Reactions: Homogeneous catalytic reactions. Determination of rate-controlling step, theories and applications of catalysis. Preparation of catalyst, measurement of catalyst surface area and catalyst poisoning	**07**
Thermodynamics of Chemical Reactions: Estimation of thermodynamic properties, feasibility of reactions, application to industrial problems. Calculation of Hof 298, So298 and Cop = a+bT+cT2 by the method of Anderson, Beyer and Watson. Use of Franklin‟s method. Method of least squares for the estimation of temperature dependence of heat capacity of a substance.	**06**
Chemical Reaction Equilibria: Criteria of chemical spontaneity and equilibria, equilibrium constant and free energy; reaction isochore and isotherm. Effect of temperature, pressure and inert gas on equilibrium constant. Homogeneous equilibria of some industrially important gas reactions. Determination of equilibrium concentrations. Equilibria of parallel and consecutive reactions. Newton‟s method of approximation in chemical equilibria calculations. Equilibria of non-ideal systems. Equilibria calculations and industrial problems.	**06**
Reactor Design: Introduction to reactor design. Broad classification of reactor types: adiabatic and non-adiabatic batch, mixed flow and plug flow reactors. Space time and space velocity of flow reactors. Comparison of flow reactors, selectivity in flow reactor. Behavior of ideal flow reactors; plug flow reactors and their combinations for single and multiple reactions (series, parallel and series-parallel); recycle reactors. Introduction to packed bed, moving bed and fluidized bed reactors.	**07**
Application of Mathematics to Technological Problems: Graphical methods of correlation of data; addition; subtraction; integration and differentiation. Chemometrics such as least square method, Yates pattern, experimental design.	**02**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Plan and interpret experimental data to determine kinetic parameters for chemical reactions.
- Identify and formulate problems in chemical reaction engineering and find appropriate solutions.
- Understand the different importance of kinetic and thermodynamic considerations for the choice of reaction feasibility and spontaneity.
- Make qualified choices of optimal reactor design, Batch, CSTR or PFR, or configurations of reactors in series.
- Establish and follow a selection process to determine the most appropriate reactor type for a specific process.
- Carry out reactor sizing calculations to the level of detail required.
- Explain and apply the principles of various characterization techniques for catalyzed reactions.

Reference Books:

- Hill, C. G. "An Introduction to Chemical Engineering Kinetics and Reactor Design."John Wiley & Sons.
- Levenspiel. O, "Chemical Reaction Engineering", John Wiley & Sons.
- Smith. J. M., "Chemical Engineering Kinetics", McGraw-Hill book Co.
- Fogler, H. C., "Elements of Chemical Reaction Engineering", Prentice-Hall Inc.
- K. J. Laidler, Chemical Kinetics, 3rd Ed. Pearson Education Inc.
- J. Rajaram, J. C. Kuriacose, Kinetics and Mechanisms of Chemical Transformations, McMillan India Ltd.
- S. K. Upadhayay, Chemical Kinetics and Reaction Dynamics, Anamaya Publishers, New Delhi.
- J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry Vol II, Plenum Press, New York.

ACCE2102: Chemical Technology-II **Credit: 3.0**

3 Hours/Week

Description:

This course is designed to introduce various chemical industries in Bangladesh. Starting from raw material to packaging this course offers many important product based industry e.g., Glass, Cement, Urea as fertilizer, TSP,SSP , Sulfuric acid etc. All of these are considered as very important material in many aspects. Raw materials, production, purification, thermodynamics,

equilibrium, kinetics, commercial processes to manufacture, construction of major equipments, technological developments etc. are the common topics highlighted for every product discussed in this course.This course also introduces a student to know about every possible problem encountered during the production of the materials.

Objectives:

The curriculum is designed to prepare chemical engineering graduates for further education and personal development through their entire professional career. We strive to accomplish these goals by providing a rigorous and demanding curriculum that incorporates lectures, discussions, laboratory and project development experiences in the field of different industries including Glass, Cement, Nitrogen and Phosphorus industries in Bangladesh. Studies in chemical technology will help to provide chemical engineering students with a strong technical education and communication skills that will enable them to successful careers in a wide range of industrial and professional environments and our general professionalism and work ethics.

Contents:	**No. of Classes**
Glass Industries: Definition, composition and classification. Methods of manufacture of different types of glasses and glass wares. Raw materials, manufacturing steps, glass furnaces and their operation, chemical reactions in the furnace. Manufacture of special glasses (fused silica glass, high silica glass, borosilicate glasses, optical glass, safety glass, Photo form and Photochromic glasses, glass composites).The glass industries in Bangladesh.	**06**
Cement and Lime Industries: Definition of cement and cementing. Basis of classification of cements. Types of cements. Constituents and properties of cement. Strength of cement. Method of manufacture of ordinary and other types of Portland cement. Cement kilns their design and operations. Cement industry in Bangladesh. Lime and its physical properties. Raw materials and methods of production. Lime kilns their design and features. Operation of lime kilns. Use of lime and lime industries in Bangladesh.	**07**
Nitrogen Industries: Methods of nitrogen fixation. Modern process for manufacture of ammonia, ammonia oxidation and nitric acid manufacture. Technological aspects of ammonia production. Theoretical basis and chemistry of urea manufacture: production and purification of synthesis gases in ammonia plants. Thermodynamics, equilibrium, kinetics and catalysis of ammonia synthesis. Commercial processes to manufacture urea-Stamicarbon process, Snamprogetti process etc. Recent technological developments, prospect of urea fertilizer industries in Bangladesh. Design aspects of ammonia synthesis converters, urea autoclave, pipe reactors, prilling tower. Retrofitting, upgrading and modernization of existing plants. Fertilizer storage and handling.	**08**

Sulfur Industries: Sources of sulfur and other raw materials of the sulfuric acid industries. Frasch process for mining sulfur. Sulfur recovery from sulfide and sulfate ores. Sulfur recovery from waste sulfuric acid and wastes of natural gas plants and fuel gas plants. Details of the manufacture of sulfuric acid by the Chamber and the Contact processes. Utilization of hydrogen sulfur, sulfur dioxide, and sulfur wastes of sulfuric acid and carbon disulphide plants and sulfuric acid industries in Bangladesh. **04**

Phosphorus Industries: Basic principles of the industrial processes for the manufacture of elementary phosphorus, phosphorus pentoxide, phosphoric acid and other important phosphorus compounds. Details of the processes for the manufacture of SSP, TSP and other phosphatic fertilizers. Phosphorus industries in Bangladesh. **03**

Learning Outcome:

After the successful completion students will be able to-

- Understand basic manufacturing and finishing process of Glass, Cement and Urea etc.
- Differentiate between various manufacturing processes
- Understand the fundamentals of Sulfur and Phosphate industries.
- Analyze different types product and can propose a noticeable development for the massive production of the materials.

Reference Books:

- Elementary Principles of Chemical Processes –Pelder & Rousseal.
- A Text book of Engineering Chemistry - M. M. Uppal.
- Shreve's Chemical Process Industries - Austin.
- Industrial Chemistry, B. K. Sharma
- Industrial Chemistry-R. K. Das
- "Handbook of Fertilizer Technology", Fertilizer Association of India, New Delhi.
- "Production of Fertilizers (Booklets 1 to 8)", European Fertilizer Manufacturers' Association.
- "Mineral Fertilizer Production and the Environment (Part 1 & 2)", International Fertilizer Industry Association.
- "Pollution Prevention and Abatement Handbook", The world Bank Group.
- N. N. Melnikow: Chemistry of Pesticides (Springer).
- M. B. Green, G. S. Hartley West: Chemicals for crop protection and pest managements (pergamon).
- R. Cremlyn: Pesticides

ACCE 2103: Physical Chemistry-II **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to introduce students with the basic concepts of physical chemistry. The course includes various definitions, mechanisms, theories, properties, applications etc. for giving students a deep insight of physical chemistry. The fundamental concepts related to phase equilibria, surface chemistry, colloid science, electrochemistry and photochemistry are explicitly stated in this course.

Objectives:

The main objectives of this course are to help students to:

- Understand various important physico-chemical processes,
- Deepen the basic knowledge of physical chemistry that will be helpful for them if they take advanced courses of physical chemistry in future.

Contents:	**No. of Classes**
Phase Equilibria: Phase rule and its application to one and two component system (including phase diagram for systems of two volatile liquids in which Raoult's law obeyed), partially miscible liquid pairs, upper and lower consulate temperature, principle of fractional distillation, constant boiling mixture, and eutectic, peritectic, eutectoid and peritectoid reactions.	05
Surface Chemistry: Adsorption at gas-solid interface, physical and chemical adsorption, Langmuir and BET theory and surface area determinations, Gibb's adsorption isotherm.	04
Colloids: General methods of preparation, classification and general properties of colloid. Electro kinetic phenomena and their analytical applications. Colloidal electrolytes, preparation, specific properties and stability of emulsion. Use of colloids and emulsion.	05
Electrochemistry-I: Conductance of electrolytes, Specific conductance, Molar conductance, Equivalent conductance. Equivalent conductance at infinite dilution for strong and weak electrolytes. Electrolysis: Theory of electrolytic dissociation. Arrhenius theory of ionization, solvation of ions, migration of ions. Transport number and its determination. Kohlrausch's law, conductometric titration	05
Electrochemistry-II: Classification of electrodes of the 1st and 2nd kinds, reversible and irreversible electrochemical processes, standard electrode potentials, redox potentials, Nernst's equation for electrode potential, concentration cells, redox cells, fuel cells, photo galvanic cells, free energy, entropy and enthalpy of cell reactions; determination of pH,	05

activity coefficients, equilibrium constants and solubility products from EMF measurements.

Photochemistry: Quantized energy and photons; The Beer-Lambert law; laws of photochemistry; quantum yields; photosensitized reactions; photophysical processes; experimental techniques in photochemistry: light sources, window materials, filters, electronics and data analysis; Actinometry: Chemical actinometers in the vacuum ultraviolet (VUV) and ultraviolet (UV) regions. 0**4**

Learning Outcomes:

Having successfully completed this course student will be able to:

- Understand the basic of surface- and colloid chemistry from a physical and chemical perspective.
- Construct phase diagrams given sufficient information and to obtain relevant information from phase diagrams.
- Learn the basic concepts of conductance and conductometric titration curves, electrolysis, transport number of ions etc.
- Understand electrochemical processes, different types of cells, emf and its applications in determining various parameters such as pH, activity coefficient, equilibrium constant, solubility products etc.
- Learn the basic concepts of photochemistry and its applications.
- Function as a member of an interdisciplinary problem solving team.

Reference Books:

- Text Book of Physical Chemistry - S. Glasstone.
- Principles of Physical Chemistry – Arun Bahl, B.S.Bahl and G.D. Tuli
- Principles Physical Chemistry- Haque and Mollah
- Practical Physical Chemistry – Findlay
- Chemical Thermodynamics - Steiner.
- Thermodynamics for Chemistry - S. Glasstone.
- Phase Rule - A. Findlay (Revised by Campbell)
- Introduction to Electrochemistry - S. Glasstone.
- Physical Chemistry – Borrow
- Electro Chemistry- B.K. Sharma

ACCE-2104: Organic Chemistry-II **Credit: 3.0**
3 Hours/Week

Description:

This course will introduce Basic concepts of organic reactions, Nucleophilic Substitution and Elimination Reaction, Reactive Intermediates, Stereochemistry, Carbohydrates and Common Unit Processes (Named Reactions).

Objectives:

The major objectives of the course are to provide knowledge on:

- The different types of organic reactions and intermediates, Thermodynamic aspects of Transition states and products, synthetic strategy of organic compounds.
- Reaction mechanisms of SN1, SN2, E1, E2 with reference to the transition states,
- Stereochemistry, Effect of Solvent, Effect of Substrates etc,
- Stereoisomerism and related topics including optical isomerism, Criteria and properties and separation, Absolute and Relative Configuration, Conformations and Relative energies of conformers of ethane, n-butane and cyclohexane
- Carbohydrate chemistry-classification, Structural analysis of D-Glucose, open chain cyclic structure of D-Glucose, mutarotation, Reactions of D-Glucose.
- Mechanism of Common Organic reactions including Friedel Craft reaction, Wittig Reaction, Heck, Suzuki and Sonogashira Coupling Reactions, 1,3-Dipolar Cycloaddition, Diels Alder Reaction etc.

Contents: **No. of Classes**

Basic Concepts: Types of organic reactions, reaction intermediates, thermodynamic and kinetic products, inductive effect, stereoelectronic effect, conjugation, hyperconjugation, synthesis and retrosynthesis, retrosynthesis of some common organic compounds, 100% atom economic processes (Green Chemistry). **02**

Nucleophilic Substitution and Elimination Reaction: Mechanism of SN^1, SN^2 reactions with clear demonstration of the intermediates, effect of substrate and reaction condition on nucleophilic substitution (SN^1, SN^2) and elimination (E1, E2) reactions, effect of nucleophile on elimination versus substitution reaction, the role of leaving group in elimination versus substitution reaction. **06**

Reactive Intermediates: Free radical, carbene and carbanion and their formation. Free radical initiators such as peroxides and AIBN, tributyltinhydride, radical stability, radical chain reactions, selectivity in radical chain reaction, controlling radical chains. **08**

Stereochemistry: Geometric and optical isomerism, elements of symmetry, chirality and prochirality. Concept of enantiomers, diastereomers, epimers. Relative and absolute **04**

configuration, determination of *R,S*-configuration. Chirality of allenes and bi-phenyls. Stereoselectivity, racemic modification, resolution of racemates. Difference of conformation and configuration, Conformation of ethane, butane, cyclohexane and substituted cyclohexane, stability of chair and boat conformation of cyclohexane, ring inversion, 1,3-dihedral interaction.

Carbohydrates: Definition and classification of carbohydrates, nomenclature, open chain and ring structure of glucose, mutarotation. Reactions including oxidation, osazone formation, chain increasing and shortening of monosaccharides. Chemistry of disaccharides, starch and cellulose with reference to the type of linkages between the anhydroglucose units. **04**

Unit Processes: The general reaction, reaction conditions and mechanisms of the following: Friedel-Crafts alkylation and acylation, alcoholysis, ammination, hydroformylation, condensation, Wittig reaction, Hoff's rearrangement, pinacole rearrangement, pericyclic reactions such as Diels Alder reaction, 1,3-dipolar cycloadditions, coupling reactions such as Heck, Suzuki and Sonogashira reactions. **04**

Learning Outcomes:

On Completion of the course the students will be able to:

- Explain different types of reactions and reaction intermediates, transition state and stability of products, retrosynthesis of representative molecules, mechanism and different factors of nucleophilic substitution and elimination reactions.
- Explain stereochemistry of optically active organic compounds, resolution of racemic mixtures, determine R,S configuration of compounds with and without chiral center, conformational analysis of ethane, n-butane and cyclohexane.
- Explain carbohydrate Chemistry with special focus on classification, mutarotation, Cyclic structure and reactions of D-Glucose.
- Understand Mechanism of Common Organic reactions including Friedel Craft reaction, Wittig Reaction, Heck, Suzuki and Sonogashira Coupling Reactions, 1,3-Dipolar Cycloaddition, Diels Alder Reaction etc.

Reference Books:

- Organic Chemistry: Clayden, Greeves, Warren and Wothers, Oxford University Press, 2001, NY.
- Organic Chemistry: Robert T. Morrison, Robert N. Boyd, Prentice Hall of India, 5th Ed. 1990, New Delhi.
- Organic Chemistry, Vol.-II: I. L. Finar, Longman, Low Price Ed.
- A Guide Book to Mechanism in Organic Chemistry: Peter Sykes, Longman, 6th Ed. 1986.
- Stereochemistry of Carbon Compounds: Ernest Eliel, Tata McGraw-Hill Ed. (1975), 38th

Reprint 2008, New Delhi.

ACCE 2105: Organic Synthesis Sessional **Credit: 1.5**
3 Hours/Week

Description:

This is a practical course that involves the synthesis of organic materials. The students have the opportunity to prepare selective organic materials that exhibit important properties. The materials and chemical syntheses have been chosen so as to illustrate the large variety of properties encountered in organic materials and, to provide practical experience covering a wide range of preparative methods.

Objectives:

- To give the competence to critically evaluate the methods for preparing organic materials.
- To devise feasible routes for the synthesis of organic materials.
- To give skills to synthesize pharmaceutical API, organic dye benzimidazole derivatives and so on.

Contents: **No. of Classes**

- Acylation Reaction: Synthesis of aspirin and acetanilide **16**
- Dye Synthesis: Synthesis of diazonium compound, synthesis of methyl orange, phenophthalein and methylene blue. Oxidation of alkyl group: Synthesis of benzoic acid from toluene
- Esterification: Synthesis of ethylbenzoate
- Synthesis of chalcone and benzimidazole derivatives
- Synthesis of the alkylsulfonate type detergent.

Learning Outcomes:

The learning outcome of the course is that the student demonstrates the ability to synthesize various organic materials of distinct uses, by using different pathway of reaction.

Reference Books:

- Modern Organic Synthesis in the Laboratory' by Chris Limberakis, Derek A. Pflum, and Jie Jack Li

ACCE 2106:Physical Chemistry Sessional **Credit: 1.5**
3 Hours/Week

Description:

The goal of the sessional course is to provide a modest introduction to this area of scientific activity. Centuries of empiricism have been invested in man's present conceptual view of the physical world. It would be impossible to attempt to illustrate systematically the experimental basis of that view. Some principles will be illustrated in the labs, but many more will simply be applied to the problem at hand. Experimental work is an eminently practical activity. The program is designed to provide a limited encounter with its methods, its fruits, and undoubtedly with some of its frustrations as well.

Objectives:

Students who successfully complete this course will be able to:

- Understand the connection between practical techniques and lecture material presented in Physical Chemistry I (ACCE 1102) and II (ACCE 2103).
- Work in a physical chemistry laboratory in a safe and responsible manner, both individually and as part of a team.
- Use different methods for the collection, processing, analysis of experimental data.
- Assess and quantify uncertainties in physical measurements.
- Present and discuss experimental results in the form of a clear, concise scientific report.

Contents: **No. of Classes**

- **Determination of Molecular Weight:** Vapor density method; Cryoscopic method. **16**
- **Thermochemical Measurement:**
  - Determination of heat of solution calorimetrically and by measuring solubility.
  - Determination of heat of neutralization of a strong base by a strong acid.
- **Study of Phase Equilibrium:**
  - Study of the mutual solubility of partially miscible systems with and without impurity.
  - Phase-diagram of the completely miscible binary liquid pair.
  - Phase-diagram from coding curves of binary solid systems.
- Viscosity and density measurement
- Determination of the radius of glycerine molecule from viscosity measurements.
- Determination of the partial molal volume of sodium chloride at different molalities.
- Determination of partition co-efficient of iodine between water and carbon tetrachloride.

- Determination of the equilibrium constant of the reaction: $KI + I_2 \leftrightarrow KI_3$
- Detemination of energy of activation of the reaction $5KBr + KBrO_3 + 3H_2SO_4 = 3K_2SO_4 + 3Br_2 + 3H_2O$
- Determination of the 2nd-order velocity constant of the hydrolysis of ethyl acetate by sodium hydroxide.

Learning Outcomes:

At the successful completion of the course student will able to determine the molecular weight, heat of solution, viscosity, energy of activation, equilibrium constant and so on .

Reference Books:

- Garland, Nibler and Shoemaker; Experiments in Physical Chemistry, 8th edition. McGraw-Hill, 2009 (GNS)

MAT 2101: Multivariable Calculus **Credit: 2.0**
2 Hours/Week

Description:

This course consists of two parts. One is differential calculus part, and the other part is integral calculus. The first part includes vector valued functions of a single variable and partial differentiation. Later part includes multiple integrals, gradient, divergence, curl etc.

Objectives:

The purpose of this course is to provide the basic concepts of graph, function of several variable, calculus and applications of calculus in engineering. Calculus is one of the most useful mathematical courses a student of engineering will ever take. Applications of calculus to science and real life are numerous.

Contents:	**No. of Classes**
Differential Calculus	
Vector-valued Functions of a Single Variable: Limits, derivatives and integrals of vector valued functions; Tangent lines to graphs of vector-valued functions; Curvature of plane and space curves.	**06**
Partial Differentiation: Functions of several variables; Limits and continuity; Partial derivatives; Differentiability, linearization and differentials; The Chain rule; Partial derivatives with constrained variables; Directional derivatives, gradient vectors and tangent planes.	**04**

Extrema of functions of several variables, Lagrange multiplier	**02**
Taylor‟s formula (in one and in several variables).	**02**
Integral Calculus	
Multiple Integrals: Double and triple integrals and iterated integrals. Area as a double integral; Double integrals in polar form; Volume as a triple integral; Triple integral in cylindrical and spherical polar coordinates.	**05**
General multiple integrals; Change of variables in multiple integrals; Jacobians.	**04**
Gradient, divergence, Curl, Green ' s theorem, Gauss ' s theorem.	**02**

Learning Outcomes:

Vector analysis, which had its beginning in the middle of the 19th Century, has in recent years become an essential part of the mathematical background required of engineers, physicists, mathematicians and other scientists. The requirement is far from accidental, for not only does vector analysis provide a concise notation for processing equations arising from mathematical formulations of physical and geometrical problems but it is also a natural aid in forming mental pictures of physical and geometrical ideas. In short, it might very well be considered a most rewarding language and mode of thought for physical sciences.

After successful completion of the course, students will be confident and skilled enough to work out problems of sketching graph of any equation, calculating the area and volume of any matter and also able to find out the maximum and minimum value of any real life function and some important applicable vector theorems in physical sciences.

Reference Books:

- H. Anton et al, Calculus with Analytic Geometry.
- E. W. Swokowski, Calculus with Analytic Geometry.
- G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Addison Wesley; 9 edition (August 14, 1995).
- J. Stewart, Single Variable Calculus: Early Transcendentals, Cengage Learning; 7 edition (2012).

PHY 2101: Fundamentals of Electronic Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to cover basic concepts of Alternating current and Varying current, RLC transients, Network Theorems, Methods of analysis, Polyphase systems etc.

Objectives:

- To prepare the students to have a basic knowledge in the analysis of Electric Networks.
- To solve the given circuit with various theorems and methods.
- To analyze the various three phase circuits star and delta connections.
- To distinguish between tie set and cut set methods for solving various circuits.
- To design various types of filters etc.

Contents:	**No. of Classes**
Alternating Current and Varying Current: Generation of AC, RMS Value, Power Factor, CR and LR Circuits, Gain, Decible, Use of Complex Variable, LCR Circuits Series and Parallel Circuit., Q-Factor. Transformer. Varying Current: Transients, Decay and Growth of Current, LCR Circuit	**03**
RLC Transients: RLC circuit response to DC input: Underdamped, Overdamped, Critically Damped Case, Charging and Discharging Phase.	**03**
Series and Parallel AC Circuits: Impedance and Phasor diagram, Series Configuration, Voltage divider rule, Admittance and Susceptance, Parallel ac Networks, Current Divider rule.	**04**
Methods of Analysis – AC networks: Independent versus Dependent sources, Mesh and Nodal Analysis, Wye-Delta and Delta-Wye Conversions.	**04**
Network Theorems – AC networks: Superposition Theorem, Thevenin‟s Theorem, Norton‟s Theorem, Maximum Power Transfer Theorem, Substitution, Reciprocity and Millman‟s Theorems.	**03**
Power – AC networks: Average, Apparent and Reactive Power, The Power Triangle, The Total *P*, *Q* and *S*, Power Factor Correction	**04**
Polyphase 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.	**05**

Decibels, filters and Bode plots: R-C Low-pass filters, R-C high pass filters, Pass-band filters, Stop-Band filters, Bode Plots **02**

Learning Outcomes:

At the end of this course students will be able to -

- Mathematically describe various types of circuit;
- Apply many established Laws to analyze voltage and current relationships in circuits;
- Define series and parallel AC circuits;
- Apply formal node analysis to analyze the operation of basic circuits;
- Use many network theorems
- Describe polyphase system
- Explain low-pass filter, high pass filter, pass band

Reference Books:

- Alternating-Current Circuits by Russell M.; Corcoran, George F. Kerchner.
- Fundamentals of electric circuits by Charles K. Alexander, Matthew N.O. Sadiku.

Semester – II

ACCE 2201: Fluid Mechanics **Credit: 3.0**
3 Hours/Week

Description:

This is an introductory course which covers important topics in fluid mechanics. In the statics part of fluid mechanics, basic concepts, laws and properties of fluids are discussed. Concepts such as viscosity, compressibility and surface tension are discussed in an elaborative manner. It also includes stress-strain rate relation discussions, topics on hydrostatic pressure and hydraulic head and discussion on related problem solving approaches. In the dynamics part, the continuum hypothesis, boundary layers, Bernoulli and Euler equations, Navier-Stokes equations, and different flow measuring devices are discussed.

Objectives:

To help students

- Understand the basic fluid mechanics including fluid statics, basic equations and principles and related measurements and calculations
- Acquire extensive knowledge on pressure measuring devices and their applications

- Comprehend different types of fluid and flow conditions
- Able to solve practical engineering problems such as problems related to energy of fluid flow

Contents: **No. of Classes**

Fluid properties: Pressure and Head. Measurement of pressure. Relationship between gauge, Absolute and atmospheric pressure. Concept of shear stress. Young-Laplace equation. Classification of fluid behavior. Conservation of mass. Conservation of energy. Dimensionless analysis. **06**

Fluid Statics: Pressure acting on a fluid prism at rest. Pascal‟s Law. Hydrostatic equilibrium. Euler‟s differential equation of hydrostatic equilibrium. Basic equation of hydrostatic and its practical application. Pressure variation in a static fluid of different surfaces. **08**

Fluid Dynamics: Mechanism of fluid flow. Distribution of fluid velocities. Euler‟s differential equation for fluid dynamics. Steady and unsteady flow processes. Bernoulli equation. Application of Bernoulli equation. Flow measuring devices: Venturi meter, Orifice meter, Pitot tube. Flow regimes. Darcy formula. Friction factor and Moody diagram. Pipes and fittings. Flow obstruction losses. Fluid power. Fluid momentum. Application of momentum equation. Navier-Stokes equations in different co-ordinate systems. **14**

Learning Outcomes:

At the end of the course, learners will be able to:

- Understand the fundamentals of fluid mechanics
- Define, describe and identify different fluid properties, flow types and behavior of fluids
- Solve related practical/engineering problems along with dimensional analysis
- Use equations and relevant charts and tables to predict pressure drops, forces on planes and analyze fluid flow
- Identify different flow and pressure measuring devices.

Reference Books:

- Franzini, J.B, Finnemore, E.J. and Daugherty, R.L., 1997. Fluid Mechanics with engineering applications. McGraw-Hill College.
- Shames, J. H., “Mechanics of Fluid”, McGraw-Hill. 1992.
- Darby, R., “Chemical Engineering Fluid Mechanics”, Marcel Dekker, 1996.
- Wilkes, J. O., “Fluid Mechanics for Chemical Engineers”, Prentice-Hall International Series, 1998.
- Streeter, V. L., “Fluid Mechanics” McGraw-Hill, 1985.

- Streeter, V. L., Wylie E. B. and Bedford, K. W. "Fluid Mechanics, 9th Edn.", McGraw-Hill Book Company, New York, 1998.
- Seshadri, C. V. and Patankar, S. V., "Elements of Fluid Mechanics", Prentice Hall of India Ltd., 1971.
- Coulson, J. M. and Richardson, J. F., "Chemical Engineering, Vol. I & II", Pergamon Press, Oxford, 1991.
- McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", McGraw-Hill, 2004

ACCE 2202: Chemical Engineering-II

Credit: 3.0
3 Hours/Week

Description:

The course of chemical engineering will acquaint pupil with different terms, facts, concepts, principles, laws and their applications related to separation processes such as filtration, drying and membrane separation techniques. This course also covers basic concepts, equipment's, materials balances and design calculation of (a) filtration processes, (b) drying processes, (c) membrane separation processes and (d) refrigeration.

Objectives:

After the completion of this course students will be able to-

- Differentiate basic equipment of filtration, separation and their industrial applications.
- Learn drying principles and various types of drying techniques and equipment.
- Understand the basic theories, concepts and application of different types of refrigeration and air conditioning systems.
- Know different types of refrigerants, their properties related to refrigeration design and calculation.
- Perceive knowledge on industrial refrigeration system.
- Learn principles, basic concepts and applications of membrane separation processes such as MF, UF, NF, GP, VP, PV, D, ED etc.
- Assimilate membrane preparation and characterization techniques.
- Gather knowledge of different types of membrane modules and their maintenance techniques.

Contents: **No. of Classes**

Theory of Filtration, Centrifugation and Sedimentation: Equipment for filtration; Bag filter, centrifugal separator, gravity settler, centrifuges, thickeners, classifiers, cyclones principle of action and industrial application, centrifugal sedimentation. **07**

Drying of Solids: Drying equipment. Principles of drying. Drying of porous solids and flow of water by capillary. Drying time under constant drying conditions. Drying time under variable drying conditions. Drying of hygroscopic porous solids. **07**

Refrigeration and Air conditioning: Basic theory, compression and absorption refrigeration cycles. Low-pressure and high pressure side of a refrigeration system, Heat pump. Ammonia absorption machines. Refrigerants. Temperature-entropy and pressure-enthalpy relations of refrigerants. Applications of refrigeration. **06**

Membrane Engineering and Technology: Introduction, principles of membrane separation processes. Basic concept on membrane separation processes such as MF, UF, NF, GP, VP, PV, D, ED etc. Membrane preparation and characterization, the membrane transport mechanisms. Fluxes and driving forces in membrane separation processes. Chemical and electrochemical equilibrium in membrane systems. Membrane bioreactor. Osmosis and reverse osmosis. Concentration polarization and fouling in membrane separation processes. Application of membrane technology. **08**

Learning Outcomes:

After the successful completion of this course students will be able to learn the basic theory of some very common unit operations, equipments necessary to operate this process and comparative study of many types of equipment having some function. Students will understand the function and operation of refrigeration and membrane technology at the end of the session.
Learners will be able to solve practical problem related to these sub units after completing this course.

Reference Books:

- McCabe, W. L., Smith J. C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
- Coulson, J. M. and Richardson, J. F., "Chemical Engineering, Volume I", Pergamon Press
- Badger, L.W. Banchero, T. J., Introduction to Chemical Engineering, McGraw Hill.
- Shames, I. H., "Mechanics of Fluids", McGraw-Hill, Inc.\
- Geankoplis, C. J., "Transport Processes and Unit Operations", Prentice-Hall Inc.
- Heiner Strathmann, LidiettaGiorno, Enrico Drioli., An Introduction to Membrane Science and
  Technology. Consiglio Nazionale DelleRicherche, Institute on Membrane Technology, CNRITM, University of Calabria, Italy, 394, 2006.
- Atkins P. W. Physical Chemistry, Oxford University Press, Oxford, UK, 1990.

- Mulder M., Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht,
  II Edition 1996.
- Noble R. D., Stern S. A., Membrane Separations Technology, Principles and Applications, Elsevier, Amsterdam, 1995.
- Ho W., Sirkar K. K. Membrane Handbook, van Nostran Reinhold, New York, 1992.

ACCE 2203: Inorganic Chemistry-II **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to teach essential concepts and understanding related to elements of periodic tables: namely, the group chemistry such as, hydrogen, inert gases, alkali and alkaline earth metals,Group IIIA, IVA, VA, VIA and VIIA Elements. General characteristics of the elements, their properties, comparative study of the elements within the group and with the elements of the other group, transition metal elements and their compounds, the stereochemistry of the complex compounds and their stability and finally industrial applications are present. Organometallics such as carbonyl, nitrosyls, metallocenes, their properties, uses are also included.

Objectives:

Students will able to learn-

- The basic properties of individual elements of periodic table
- Group chemistry and group properties. Comparative study among the group elements.
- Separation techniques of inert gases mixture from air, separation of individual inert gases from the mixture, uses of inert gases.
- Transition metals, their properties, their compounds and catalytic activities of these elements.
- Organometallic compounds such as carbonyl compounds, nitrosyl compounds, metallocenes, and their catalysis properties etc.

Contents:	**No. of Classes**
Hydrogen: Occurrence, preparation and uses of hydrogen. Compounds of hydrogen.	03
Inert Gases (elements of zero group): Isolation and industrial applications.	03
Alkali and Alkaline Earth Metals: Comparative study of the elements and some of their compounds in the alkali and alkaline-earth metals	04

Group IIIA, IVA, VA, VIA and VIIA Elements: General characteristics and group properties 10

Transition Metals: Complex compounds of transition metals. A study of stereochemistry (4 & 6 coordinated metal complex equilibria and stability systems). Industrial & analytical application of complex compounds. The catalytic behavior of transition metals and their compounds. 04

Organometallics: Metal carbonyls, metal nitrosyls, metallocenes, catalysis by organometallic compounds. 04

Learning Outcomes:

On successful completion of this course students can

- Have a broad knowledge of the properties and concepts of contemporary chemistry of group IA to group VIIA, including transition metals.
- Elucidate the electronic structure of a variety of transition metal complexes.
- Describe the structure and properties of different classes of transition metal compounds.
- Explain the occurrence and formation of metal carbonyls, metal nitrosyls etc.
- Describe the occurrence, preparation and compounds of hydrogen.

Reference Books:

- Advanced Inorganic Chemistry - Cotton & Wilkinson.
- Inorganic Chemistry-R. D. Madan.
- Descriptive Inorganic Chemistry- Geoff Rayner- Canham.
- Introduction to Modern Inorganic Chemistry - S. Z. Haider.
- Advance Inorganic Chemistry S. Z. Haider.
- Basic Inorganic Chemistry - Cotton & Wilkinson.
- Nuclear & Radiochemistry - Friedlander & Kannedy.

ACCE 2204 : Fundamentals of Computer Science and Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course is an introductory course that highlights on the fundamentals of computer science and engineering. Digital literacy is a prerequisite for creating a more efficient and fast workforce. This course gives a holistic idea on the operating systems, computer software and programming.

Objectives:

To help students to:

- Understand the basic knowledge on how computer works
- Get familiarized with programming
- Understanding the software classification and development
- Acquire knowledge on computer processors and memory.

Contents: **No. of Classes**

Number systems, codes, logic functions, data representation and codes, binary numbers. **05**

Microcomputers and Microprocessors: Microcomputer organization, basics of microprocessors, popular microprocessors. Memory organizations: Main memory; secondary memory. **05**

Computer software: Introduction and classification, system software, application package programs, high level languages and software development cycle. **06**

Operating Systems: Functions and types, Windows and Linux operating systems. **05**

Computer Programming: Basic C language. Object oriented programming using C++, MATLAB. Networking. **07**

Learning Outcomes:

At the end of the course, learners will be able to:

- Perform basic programming and understand networking.
- Understand the inner workings of different operating systems.

Reference Books:

- Stroustrup, Bjarne. The C++ programming language. Pearson Education India, 2000..
- Brookshear, J. Glenn, and Dennis Brylow. Computer Science: An Overview Pearson Education, 2017.

ACCE 2205: Inorganic Preparation Sessional **Credit: 1.5**
3 Hours/Week

Description:

This is a practical course that involves the synthesis of inorganic materials. The students have the opportunity to prepare selective inorganic materials that exhibit important properties. The materials and chemical syntheses have been chosen so as to illustrate the large variety of properties encountered in inorganic materials and, to provide practical experience covering a wide range of preparative methods.

Objectives:

- To give the competence to critically evaluate the methods for preparing inorganic materials.
- To devise feasible routes for the synthesis of inorganic materials.
- To give skills to synthesize inorganic materials using crystallization technique.

Contents: **No. of Classes**

Preparation of pure sodium chloride, iron(II) sulphate heptahydrate, Mohr's salt, chrome alum, potash alum, sodium hydrogen carbonate, sodium cobalt nitrite, CuO from copper turnings. **16**

Learning Outcomes:

The learning outcome of the course is that the student demonstrates the ability to synthesize inorganic materials using crystallization technique on a laboratory scale.

Reference Books:

- Handbook of Preparative Inorganic Chemistry (Vol. 1, 2nd Edition) – Georg Brauer.
- Synthesis of Inorganic Materials – Ulrich Schubert and Nicola Husing.

ACCE 2206: Engineering Drawing Sessional **Credit: 2.0**
4 Hours/Week

Description:

This is an introductory course which focuses on preparing drawings, sketches, engineering designs to transfer an idea into reality. The engineering drawing helps student in improving their spatial visualization, technical communication and technical drafting. This course will also provide the knowhow of Computer Aided Drafting (CAD) software and their use in drafting and designing.

Objectives:

To help students-

- Develop skills in understanding, interpreting and producing diagrammatic illustration of technical standards
- Acquire extensive knowledge and use of computer aided drafting software
- In growing their interest in designing and modeling skills that will help in professional life.

Contents: **No. of Classes**

- Geometrical drawing: Introduction and drawing instruments **16**
- Lettering, Dimensioning.
- Theory of projections. First angle and 3rd angle projections.
- Projections of points, straight lines, planes.
- Orthographic projections.
- Isometric projections.
- Sections of solids.
- Missing lines and views.
- **Auto CAD:** Configuring Auto CAD Software (how to install), AutoCAD's User Interface (screen color, cursor, cross hair etc.), Getting Started (Defining page limit, input unit etc.), Layers (Defining items of a drawing), Circles and Arcs, Object Snap, Fillets (making the corner of s polygon round), Object Properties, Trimming and Extending, Offsetting Objects (to draw parallels), Exporting the drawing in different format, printing etc.

Learning Outcomes:

At the end of the course, learners will be able to:

- State names of various drawing instruments and equipment displayed
- Understand, interpret and produce engineering drawing and diagrams
- Use AutoCAD to design and draft
- Develop requisite competence for technical productive work.

Reference Books:

- AutoCAD 2007 and AutoCAD LT 2007 Bible by Ellen Finkelstein.
- AutoCAD 2007 and AutoCAD LT 2007: No Experience Required by David Frey.
- AutoCAD 2007 For Dummies by David Byrnes and Mark Middle brook.
- Mechanical Engineering Drawing- Amalesh Chandra Mandal and Md. Quamrul Islam.

ACCE 2207: Field work **Credit: 1.5**

Description:

Industrial field work refers to work experience done during the program of study that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course student will visit at least two industries at the end of their second semester based on the availability of the industry located in the suitable area of the country.

Objectives:

The fundamental objective of the field work is to prepare students for future employment in their chosen industrial discipline. Field work enhances the academic material studied in second year by allowing students to practice what they have learned and to develop key professional attributes by experiencing the theoretical knowledge into practical perspective. Field work should provide an opportunity for students to:

- Correlate the theoretical knowledge with practically observed chemical industry
- Experience the discipline of working in a professional industry
- Develop understanding of the functioning and organization of a chemical process industry
- Interact with other professional and non-professional groups within the industry
- Apply engineering methods such as design and problem solving
- Develop technical, interpersonal and communication skills, both oral and written.

Learning Outcomes:

This course will offer a student to achieve ability to-

- Demonstrate the use of the product and the function of many types of equipment involved
- Analyze a given engineering problem, identifies an appropriate problem solving methodology, implement the methodology and propose a meaningful solution
- Apply prior acquired knowledge in theoretical problem solving session
- Identify sources of hazards, and assess/identify appropriate health & safety measures.
- Work in a team
- Take initiatives
- Effectively communicate solution to problems (oral, visual, written)
- Manage a project within a given time frame
- Adopt a factual approach to decision making
- Take engineering decision.

Viva-Voce **Credit: 1.0**

At the end of the year (after completing the course work of all the semester) a student will sit for an oral examination. Members of the examination committee will evaluate the students by asking questions relevant to the courses of the current year. The teacher panel interviews the students on subjects studied year-long and measure their competency and understanding.

MAT 2201: Ordinary Differential Equations and Numerical Analysis **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to cover basic concepts of first order differential equations and their solutions, higher order differential equations, Numerical analysis based on the different methods.

Objectives:

- Identify essential characteristics of ordinary differential equations
- Develop essential methods of obtaining numerical solutions
- Explore the use of differential equations as models in various applications
- Can solve initial and boundary value problems
- Explain Regula-Falsi method, Newton-Raphson method, Newton's formulae, Simpson's rule, Newton's forward and backward formula etc.

Contents: **No. of Classes**

Ordinary Differential Equations and their Solutions: Initial value problems. Boundary value problems. Basic existence and uniqueness theorems (statement and illustration only). Solutionof First Order Equations: Separable equations and equations reducible to this form. Linear equations, exact equations, special integrating factors, substitutions and transformations. **08**

Solution of Higher Order Linear Differential Equations: Fundamental solutions of homogeneous systems. Reduction of order. Homogeneous linear equations. Method of undetermined coefficients, variation parameters. Cauchy-Euler differential equations. Systems of linear differential equations (with constant coefficients): Operator method and Matrix method, Fundamental matrix. **08**

Numerical Analysis: Solution of algebraic and transcendental equations by graphical method. Regula-Falsi method. Newton-Raphson method. Geometrical significance. Interpolation: Simple difference, Newton‟s formulae for forward and backward interpolation. Divided differences. Relation between divided differences and simple differences. Newton‟s general interpolation formula. Lagrange‟s interpolation formula. Numerical differentiation: Newton‟s forward and backward formula. Numerical integration: rule, Simpson‟s rule. Calculation of errors. Principles of least squares. Curve fitting. Solution of ordinary first order differential equations by Euler‟s method, Runge-Kutta‟s method. **12**

Learning Outcomes:

At the end of this course students will be able to -

- Classify ordinary differential equations according to order and linearity, as well as distinguish between initial value problems and boundary value problems
- Solve standard homogeneous ordinary differential equations
- Use the methods of Euler, Runge-Kutta, and others to solve differential equations numerically
- Formulate and solve application problems etc.

Reference Books:

- S. L. Ross, Differential Equation.
- D. G. Zill, A First Course in Differential Equations with Applications.
- E. Kreuszig, Advanced Engineering Mathematics, 10th edition.
- R.L. Burden & J.D. Faires, Numerical Analysis
- Steven C. Chapra**,** Numerical Methods for Engineers

THIRD YEAR

Semester – I

ACCE 3101: Chemical Technology-III **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to teach essential concepts and understanding related to extraction of vegetable oils, purification of oil, difference between fats and oils, etc.In addition, essential oils, sources of essential oils and different processes of extraction of essential oils are discussed. Preparation of soaps and detergents, difference between soaps and detergents, cleansing action of soaps and detergents, preparation of cosmetics and perfumes, their raw materials and major ingredients of cosmetics and perfumes are also covered.

Objectives:

- To introduce students with basic concepts of fats, oils and waxes.
- To give an understanding about the extraction of vegetable oils, purification of oil.
- To deepen the knowledge about properties and usage and manufacturing process of soaps and detergents.

- To introduce the learners with the working mechanism of cosmetics.
- To familiarize them with different types of manufacturing processes of different types of cosmetics, their raw materials and major ingredients.

Contents: **No. of Classes**

Oils, Fats and Waxes: Extraction and reforming of vegetable oils. Animal fats and oils, hydrogenation, inter-esterification, waxes. **06**

Soaps and Detergents: Splitting of fats, fatty alcohols manufacture, raw materials, types and manufacture of soap and detergent. Cleansing action of soap and detergents. Manufacture, properties and uses of glycerin. **06**

Essential Oils, Fragrances and Flavors: Vehicle, fixative, essential oil, recovery of volatile oils, synthetics and semi-synthetic essential oils, uses, natural fruit concentrates. Perfumes-Definition, classification, synthesis and uses. **06**

Cosmetics:A general study including preparation of cosmetics and perfumes in terms of raw materials such as emulsifiers (natural, synthetic and finely dispersed solids), lipid components (oils, waxes, fats), humectants, colors (dyes and pigments), preservatives and antioxidants. Essential oils and their importance in cosmetic industries. Cosmetics for skin (Types and problems of skin, key ingredients of skin cleansing, toners, moisturizers, nourishing, protective sunscreen, talcum powder and bleaching products) and hair care (classification, special additives for conditioning and scalp health, hair colorants, the plant materials (herbs) used in hair cosmetics). **10**

Learning Outcomes:

At the end of this course students will be able to-

- Understand the different sources of raw materials, extraction methods for oils and purification of extracted oils etc.
- Differentiate between fats, oils and waxes. Characterization of fats and oils and their properties.
- Understand the fundamentals of soaps and detergents, their basic raw materials and different preparation methods, cleansing action of soaps and detergents.
- Know how to prepare cosmetics and perfumes, humectants, colors (dyes and pigments), preservatives and antioxidants.
- Extraction of essential oils, their composition and purification etc.

Reference Books:

- Shreve's Chemical Process Industries - Austin.
- A Text book of Engineering Chemistry - M. M. Uppal.

- Industrial Chemistry, B. K. Sharma
- Industrial Chemistry-R. K. Das

ACCE 3102: Chemical Engineering-III **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to introduce basic concepts and principles of mass transfer. The major topics covered include basic theories of mass transfer and their applications in industrial processes like distillation, adsorption, extraction etc. Different industrial separation techniques like freeze-drying, magnetic separation, electrostatic separation etc. are also described. Finally, different analytical, empirical and numerical techniques are introduced to solve mass transfer problems and design calculations of rectification tower.

Objectives:

The objectives of this course are to help students understand basic concepts, ideas and problems associated with mass transfer operation and to find out their solutions. The completion of the course will enable students:

- To understand basic theories and mechanisms of mass transfer operation.
- To correlate the theories of mass transfer with industrial separation techniques.
- To gain experience in designing and construction details of rectification tower.
- To develop methodologies for solving a wide variety of mass transfer problems.
- To understand the thermodynamics and kinetics of adsorption process.
- To understand the working principle of different industrial separation processes.
- To learn about different equipment required for separation of gas-solid system.

Contents: **No. of Classes**

Mass Transfer: Mass Transfer: Basic theories of mass transfer, mass transfer coefficient, application of theories of mass transfer to transfer units e.g. distillation, absorption, extraction etc. Principles of design calculations of rectification tower. **08**

Distillation: Basic theory and principles of distillation processes. Continuous and batch distillation. Design & operating characteristic of plate column, operation efficiency. Analysis of fractionating column by McCabe-Thiele method and enthalpy concentration methods, Construction details of plate column, sieve column etc., Design of rectification processes. **08**

Adsorption: Treatment of adsorption from thermodynamics and kinetics, application in process industries. **04**

Industrial Separation Processes: Sublimation, freeze-drying, molecular distillation, gaseous and thermal diffusion, jigging, tabling, magnetic separation, electrostatic separation and flotation equipment. Electrostatic precipitator. **04**

Equipment for Gas-solid System: Equipment for Gas-solid System: Static-bed systems, moving bed systems, fluidized-bed systems, pneumatic systems. **04**

Learning Outcomes:

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

- Explain what mass transfer is.
- Identify mechanisms of mass transfer and calculate mass transfer rates.
- Calculate number of plates for efficient operation of rectification column.
- Formulate and solve differential equations of mass transfer to calculate concentration distributions.
- Solve problems involving mass transfer using appropriate correlations.

Reference Books:

- Trebal, R. E. "Mass Transfer Operations", McGraw-Hill, Inc.
- McCabe, W. L., Smith J. C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
- Badger, L. W. Banchero, T. J. Introduction to Chemical Engineering, McGraw Hill.
- Coulson, J. M., Richardson, J. F., "Chemical Engineering", Volume 1 and 2, Pergamon Press.
- Foust, A. S. Wenzel, L. A., Clump, C. W., Naus, L., and Anderson, L. B., "Principles of Unit Operations", John Wiley & Sons, Inc.
- Geankoplis, C. J., "Transport Processes and Unit Operations", Prentice-Hall, Inc.
- Wilty, J. R., Wicks, C. W., Wilson, R. E. and Rorrer, G., "Fundamentals of Momentum Heat and Mass Transfer", John Wiley & Sons.
- Roshenhow, W. M. and Harry Choi, "Heat, Mass & Momentum Transfer", Prentice Hall, Inc.
- Benner, C. O., Myers, J. E., "Momentum Heat and Mass Transfer", Tata McGraw-Hill.
- Hirschfelder, et. al., "Molecular Theory of Gases and Liquids", John Wiley & Sons.
- Wetly, J. R. Wicks, C. E., Wilson, R. E., "Momentum, Heat and Mass Transfer" John Wiley & Sons.

ACCE 3103: Fuel and Petrochemical Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course includes different conventional and non-conventional energy and fuel sources, their composition and classification. It also gives basic ideas about petroleum formation, theory and technology that are used in petroleum refining processes. Petroleum refining with respect to Bangladesh perspective is also included in this course. Origin, formation and composition, classification of coal, coal gasification, liquefaction and combustion processes are also included. Petrochemicals and their processing technologies are also discussed in this section.

Objectives:

- To deepen the students' knowledge about different fuel types, origins and specific usage.
- To introduce students with different petroleum cracking and reforming processes.
- Petroleum processes and distribution in Bangladesh will give the students idea about current petroleum industry scenario in Bangladesh.
- To provide fundamental knowledge about preparation and storage, carbonization, gasification and liquefaction of coal.
- To give elementary introduction about petrochemicals and a brief history of petrochemical technology.
- To introduce student to the processes used in petrochemical synthesis.

Contents: **No. of Classes**

Introduction: Conventional and non-conventional energy sources. Types of fuels, Composition and calorific value of fuels. **01**

Petroleum: Inorganic and organic theory of petroleum formation. Geochemistry of petroleum. Composition. Classification of crude petroleum. Theory and Technology of primary and secondary petroleum refining processes; Atmospheric and vacuum distillation, Thermal cracking, Catalytic cracking, Coking, Pyrolysis, Hydrofining, Hydrocracking and Reforming. Products of petroleum processing and their uses. Environmental aspects, Petroleum in Bangladesh and it's processing in the ERL **14**

Coal: Origin of formation and composition, classification, moisture and mineral matters in coal; preparation and storage; destructive distillation, carbonization, gasification and liquefaction of coal; manufacture of metallurgical coke, peat. Effective utilization of coal in Bangladesh. **04**

Petrochemicals: Important petrochemicals and a brief history of petrochemical technology; An overview of chemistry of petroleum, primary raw materials for petrochemicals, hydrocarbon intermediates. Non- hydrocarbon intermediates, chemicals **04**

based on methane, ethane and higher paraffin's- ethylene, propylene, C-4 olefins and di-olefins, benzene, toluene, xylenes, and synthesis gas.

Petrochemical Processing: Theoretical basis, chemistry and technology of halogenation, alkylation, oxidation, hydration, dehydration, esterification, sulphation, sulphonation, nitration, dehydrogenation and hydrogenation processes used in petrochemical synthesis. **05**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Evaluate the properties of different conventional fuels, and describe, compare, and evaluate key fuel properties.
- Understand basic procedures and role of all fundamental systems used in petroleum cracking and reforming processes.
- Evaluate novel combustion technologies and identify the benefits over conventional combustion technique.
- Explain basic concepts of coal formation, methods of coal to useful fuel conversion processes and technologies for effective utilization of coal in Bangladesh.
- Demonstrate theoretical basis, chemistry and technology of petrochemical processes used in petrochemical synthesis.

Reference Books:

- J.N Harker and J.R. Backhurst, Fuel and Energy.
- B.K. Bhaskara Rao, Modern Petroleum Refining Processes, Oxford & Ibh Publishing co, 2002
- Dr. G.N. Sarkar, Advanced Petroleum Refining, Khanna Publishers, 2000.
- Dr. Ram Prasad, petroleum Refining Technology, Khanna Publishers, 2006.
- Nelson, W.L., Petroleum refining engineering, McGraw-Hill Book Co
- G. D. Hobson and W. Pohl, Modern petroleum technology, 4th Edit., John Wiley & Sons, New York (1973). 996 pages
- Benedict, M. and Pigford, T.H., "Nuclear Chemical Engineering:, McGraw-Hill Book Co.
- Bansal, N.K., Kleemann, M. and Meliss M., "Renewable Energy Sources and Conversion Technology", Tata McGraw-Hill Publishing Co. Ltd.

ACCE 3104: Analytical Chemistry & Material Testing **Credit: 3.0**
3 Hours/Week

Description:

This course emphasizes the quantitative aspects of chemistry. Starting with classical measurements of volumes and masses, the course will develop statistical tools of estimation, confidence,

accuracy, and precision in treating experimental data. This includes an introduction to instrumental methods of analysis. Standard titration methods, Thermogravimetric Analysis, Paper chromatography, Thin Layer Chromatography, Gas Chromatography, Ion exchange methods are included in this course. Moreover basic principles of material testing and different types of material testing methods are also discussed.

Objectives:

- To provide a basic knowledge and understanding of essential chemical and physical principles for analytical chemistry.
- To introduce basic analytical techniques and practical aspects of classical chemical analysis.
- To solve problems related to chemical analysis and interpret analytical results.
- To provide an understanding of chemical methods employed for elemental and compound analysis.
- To provide experience in some scientific methods employed in analytical chemistry.
- To introduce students with basic material testing processes and methods used in industries.

Contents: **No. of Classes**

Application of Statistical Methods to Chemical Analysis: Sampling in chemical analysis; significant figures; systematic and random errors; precision and accuracy; absolute and relative uncertainty; propagation of uncertainty; standard addition; internal standards; constructing a calibration curve; The Gaussian distribution; mean, true mean and median; standard, true standard and relative standard deviations, standard deviation and probability. **02**

Theoretical Basis of Quantitative Inorganic Analysis: Introduction; Activity and activity coefficient, Titrimetric Analysis- Theoretical considerations, classifications and determination of end points in precipitation, complex formation and redox reactions. Gravimetric Analysis- Methods; common organic precipitating agents; characteristics of the precipitates; super saturation; homogeneous precipitation; effect of electrolytes on precipitation; purity of the precipitates. **10**

Thermal Properties: Thermogravimetric Analysis, Differential Thermal Analysis. **08**

Chromatography: **04**

Paper chromatography: Principle, quantitative analysis, evaluation of paper chromatography as a separation method, practical applications in analytical sciences.

Thin Layer Chromatography (TLC): Principle, qualitative and quantitative analysis by TLC. Advantages over other chromatographic techniques, limitations and applications in organic analysis.

Gas Chromatography: Principles, instrumentations, injection systems, GC columns, stationary phases, packed column, capillary column, GC detectors. Gas-Liquid Chromatography, Theory, instrumentation, quantitative analysis.

Ion-exchange, Electrophoresis, Electrodialysis, Ultrafiltration.

Materials Testing: Stress, Strain, Tensile Properties, Compression Test, Hardness Test, Impact Test, Fatigue Test, Creep Test. **04**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Describe the basic principles and procedures to perform quantitative chemical analysis.
- Understand how different sampling techniques and instrumental methods can be used in speciation studies.
- Execute effective mathematical calculations necessary to achieve correct values in quantitative analysis.
- Explain the theoretical principles of various separation techniques in chromatography, and typical applications of chromatographic techniques.
- Explain fundamental material testing methods and how these can be applied for industrial purposes.

Reference Books:

- Skoog, D.A., West, D.M., & Holler, F.J. (1996). Fundamentals of analytical chemistry: Saunders College Pub.
- Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of instrumental analysis. Cengage learning.
- Alexeyev, V. (1969). Quantitative analysis.
- Harris, D. C. (2010). Quantitative chemical analysis. Macmillan.
- Harvey, D. (2000). Modern analytical chemistry (Vol. 381). New York: McGraw-Hill.
- Rouessac, F., & Rouessac, A. (2013). Chemical analysis: modern instrumentation methods and techniques. John Wiley & Sons.
- Narang, G. B. S., & Manchanda, V. K. (1984). Materials and Metallurgy. Khanna Publishers.

ACCE 3105: Electrochemical Engineering **Credit: 3.0**
3 Hours/Week

Description:

The aim of the module course is to teach the students to define, explain and understand the applications of the important terms and laws electrochemistry such as electron transfer, electrodes, sources of electrical energy, electrolysis etc. It provides the sufficient knowledge about the electrochemical industries, Chemical sources of electrical energy that are very relevant in modern times.

Objectives:

- To give basic concepts about electrochemistry and its fundamental terms.
- To introduce the students with polarization and overvoltage processes.
- To give idea about basic electrodics equations and electrochemical devices.
- To deepen the knowledge about electroplating and its industrial applications.
- To make the students familiar with fundamental electrochemical manufacturing processes.
- To introduce them with electrocatalysis.

Contents: **No. of Classes**

Basic Concepts: Electrified interface, Electrical double layer; Helmholtz-parrin model, The Gaoy Chapman model, Stern model. **02**

Polarization and Overvoltage: Polarization of electrodes, decomposition voltage, types of polarization. Classification of overvoltage, hydrogen and oxygen overvoltage. Significance of polarization and overvoltage in electrochemical manufacturing processes. Reference electrode: Standard hydrogen electrode, calomel electrode, silver chloride electrode. **06**

Electrodics: Charge transfer, electrochemical devices: substance producer, substance destroyer and Energy producer. Basic electrodic equation. The Butler-Volmer equation, symmetry factor, significance of symmetry factor, electron traffic across the interface, exchange current density and Tafel equation. Electrodic Reactions of special interest. **04**

Chemical Source of Electrical Energy: Leclanche's cell (acidic and basic), lead accumulator, Edison accumulators, silver-zinc accumulator. Fuel cell, Different types of fuel cells. **04**

Electroplating: General principles, Factors affecting electroplating, Electrolysis in the fused state, Electroplating of Ni, Cr, Zn. **04**

Electrochemical Industries: Advantages and drawbacks of electrochemical manufacturing processes, Production of caustic soda and chlorine by diaphragm, mercury and membrane cells. **04**

Electrocatalysis: A chemical catalyst and an electrocatalyst. Electrocatalysis in simple redox reaction, reaction involving adsorbed species. Electro growth of metals on electrodes. **04**

Learning Outcomes:

At the end of this course students will be able to:

- Receive an overview and in-depth understanding of fundamentals of electrochemistry, electrochemical electron transfer, electrochemical processes etc.
- Develop an idea of electrochemical kinetics, electro-catalysis, surface electrochemistry, electrochemical energy conversion processes (fuel cell, electrolysis), electrochemical methods and mass transport during electrochemical reactions.
- Learn about the importance of electrochemical kinetics and its relation to industrial electrochemical processes and also in the energy sector.

Reference Books:

- Bockris and Reddy, Modern Electrochemistry, 2nd EditionVol. 2A, Springer.
- B. K. Sharma, Electrochemistry, GOEL Publishing house
- C. M. A Brett and A.M.O Brett, Electrochemistry, Oxford University Press.
- E. Gileadi, Electrode Kinetics for Chemists, Engineer and Materials Sciences, VCH Publisher, Weikhein.
- W. Schmicker, Interfacial Electro-Chemistry, Oxford University Press.

ACCE 3106: Medicinal Chemistry **Credit: 3.0**
3 Hours/Week

Description:

This course will introduce concepts of medicinal chemistry, therapeutic agents such as analgetic and antipyretics, vitamins, hormones and alkaloids, chemotherapeutic agents and anti-cancer drugs, gastric antacids, histamines and antihistamins, antidiabetic drugs, cardiovascular drugs.

Objectives:

The major objectives of the course are to provide knowledge on:

- The different aspects of drug design including Lipiniski's Rule, drug absorption and metabolism, bioavailability etc.

- Basic concepts of therapeutic agents and their synthesis, properties, structural activity relationship, Uses, metabolism etc. Such agents will include analgetic and antipyretics, vitamins, hormones and alkaloids, chemotherapeutic agents and anti-cancer drugs, gastric antacids, histamines and antihistamins, antidiabetic drugs, cardiovascular drugs.

Contents: **No. of Classes**

Basic Concepts: The Pharmacopoeias, drugs-nomenclature, generic and branded drugs, Source of drugs, Lipiniski's rule, INN drug, Factors affecting drug absorption, diffusion of drug across membrane, Site of absorption, bioavailability, distribution of drugs, Drug metabolism. **03**

Analgetic and antipyretics: Chemical structures and actions of Narcotic analgetics such as opium alkaloids, methadone, morphines, ephidrine, epinephrine, Non-narcotic analgeics such as Aspirin, Paracetamol, Pyrazolone derivatives, dichlofenac etc. **04**

Vitamins, Hormones and Alkaloids: Water and fat soluble vitamins, Source of different vitamins, Vitamin deficiencies. Thyroid hormone and its function, Sex hormones, Adrenalines-mineralocorticoids and glucocorticoids, Belladona, Cinchona, Tropane, Nux-vomica alkaloids. **06**

Chemotherapeutic agents and Anti-cancer Drugs: Definition, Classification and uses of chemotherapeutic agents, Sulfa drugs, Antimalarials, Anticancer drugs. **02**

Gastric Antacids: Chemistry, biological action and uses of Non-systemic antacids such as aluminium hydroxide, aluminium carbonate, magnesium hydroxide and oxide, Chemistry, biological action and uses of Systemic drugs such as H_2 receptor antagonists, like ranitidine, cimitidine, omeprazole etc. **03**

Histamines and Antihistamins: Mode of action of histamine on cardiovascular system, histamine releasing components, allergic effect, Definition, General structure, examples, mode of action of H-1 Blockers, Sedative hypnotics-Definition, Biological action and synthesis of benzodiazepines. **04**

Antidiabetic Drugs: Type I and type II diabetes and related drugs such as thioureas, biguanidines, thiazolidinediones, Insulin preparation etc. **03**

Cardiovascular Drugs: Chemistry, mode of action of cardiac drugs such as glycosides (cardiotonics), - Blockers, Vasodialators, Ca-channel blocking agents, ACE inhibitors etc. **03**

Learning Outcomes:

On Completion of the course the students will be able to:

- Explain different aspects of drug design including Lipiniski's Rule, Drug absorption and metabolism, Bioavailability etc.
- Explain synthesis, properties, structural activity relationship, mechanism of action, uses, metabolism of therapeutic agents such as Analgetic and antipyretics (steroidal and non-steroidal), vitamins, hormones and alkaloids (vitamin deficiencies), chemotherapeutic agents and anti-cancer drugs, gastric antacids, histamines and antihistamins, antidiabetic drugs, cardiovascular drugs.

Reference Books:

- Essentials of Medicinal Chemistry: AndrejusKorolkovas, Wiley- Interscience, 2nd Ed, 1988, USA.
- Medicinal Chemistry: Berger

ACCE 3107: Industrial Raw Materials and Product Analysis Sessional **Credit: 2.0**
4 Hours/Week

Description:

This course is designed to develop and improve the analytical skills of students. This course includes analysis of several industrially important raw materials and products. The importance of the utilization of various analytical techniques is explicitly focused in this course.

Objectives:

- To provide students sufficient laboratory facilities so that they can improve their practical knowledge and analytical skills in chemistry.
- To help them understand the importance of some specific chemical reactions, techniques and tools for specific analytical purposes.
- To help them so that they can analyze some industrially important raw materials and products utilizing their theoretical concepts and laboratory facilities.

Contents: **No. of Classes**

- Analysis of water, Sulfur, Fuel Oil, Natural gas, Coal, Oil seeds, Cellulosic raw material, Lime & Limestone, Sea- salt (Total NaCl, sulphate, insolubles, Mn & V), Sand. **16**
- Analysis of Soap and detergents, Fertilizer, nitrogen content of urea, Bleaching powder, Refined vegetable oils, Hydrogenated fats, Animal fats and oils, Milk and

milk products, Sugar, Honey and confectionary materials, Glass (for SiO_2 , Metal oxides).

- Recovery of furfural from jute stock and different agricultural wastes.
- Accelerated tests employing simulated environment and corrosion of iron steel & copper alloys.
- Analysis of cast iron and steel (for Fe, Mn, P, Si & C).
- Analysis of Cement (for SiO_2, Fe_2O_3 + Al_2O_3, CaO, MgO & Fe_2O_3)
- Determination of neutralization power of antacid tablets.

Learning Outcomes:

At the end of this course, students will be able to learn

- How to determine the content of specific component in the supplied samples
- How to determine the purity of supplied samples
- How to predict the quality of supplied samples by measuring various parameters

Reference Books:

- Quantitative Analysis- V. Alexeyev (Mir Publishers Moscow)
- Fundamentals of Analytical Chemistry- Douglas A. Skoog, 9th Edition

ACCE 3108: Instrumental Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

This course will offer the learners to develop a practical knowledge and skill of using various instruments like pH meter, Conductivity meter, Polarimeter, Refractometer, Chromatographic technique and UV-Visible spectrophotometer and so on. This course will assist students know the characteristics and pattern of the graph upon using acids and bases of various strength. Determining the unknown concentration of any acid, base or salt are performed in this course. Students will develop a skill to interpret laboratorial results and write technical reports, and apply the laboratorial results to problem identification, quantification, and basic technical solutions.

Objectives:

- To make familiar students with instrumental analysis.
- To introduce learners with study of kinetics of chemical reactions using conductivity meter.
- Give them basic idea about pH meter and use of pH meter.
- To introduce them with UV-Visible Spectrophotometer and its usage.

Contents: **No. of Classes**

- Study of kinetics of chemical reactions using:
  (a) Polarimeter, (b) Conductance bridge, (c) Spectrophotometer and d) Chemical analyses. **16**
- Electrochemical measurements:
  (a) Measurement of cell constant, (b) Conductometric titrations, (c) Potentiometric titrations, (d) involving oxidation reduction reactions. Acid-base neutralization, (e) Determination of transport numbers, (f) pH measurements, (g) Reduction potentials for a series of metal/metal ion systems, verification of Nernst equation.
- Spectrophotometric analysis.
- Chromatographic analysis
- Refractometry.

Learning Outcomes:

At the end of this course, students will be able to -

- Differentiate between strong acids and weak acids by using pH and conductivity meter.
- Determine the unknown concentration of acids from their corresponding graph obtained by measuring either pH or conductivity.
- To measure the unknown concentration of the salt will be determined from their respective calibration curve by using UV-Visible spectrophotometer.
- Compare between actual and instrumental laboratorial results.
- Understand the utility of these instruments in analytical field.
- Obtain the necessary background for subsequent courses (spectrometric method of analysis) in upcoming semesters.
- Demonstrate the ability to write clear handwritten technical laboratorial reports.
- Demonstrate the ability to work in groups.
- Understand the possible instrumental errors encountered during the operation of these instruments and develop an ability to solve them.
- Proper maintenance of these instruments are also highlighted for the better performance in the laboratory.

Reference Books:

- Principles of Instrumental Analysis; Douglas A. Skoog
- Physical Chemistry; Peter Atkins
- Essentials of Physical Chemistry by Arun Bahl & J.D Tuli

Semester – II

ACCE 3201: Chemical Engineering-IV **Credit: 3.0**
3 Hours/Week

Description:

The course of chemical engineering-IV will acquaint pupil with different terms, facts, concepts, principles, laws and their applications related to separation processes. This course include characteristics of separation process, basic concept of ternary systems and its related terms, calculation of both single stage and multistage extraction system by using ternary diagram. The course also covers basic concepts, equipment's, materials balances and design calculation of (a) liquid-liquid extraction processes, (b) leaching processes, (c) gas absorption operation, (d) crystallization and (e) evaporator.

Objectives:

To help learners to:

- Know the meaning of terms and specific facts of the unit processes such as liquid-liquid extraction, leaching, crystallization, gas absorption and evaporation.
- Understand concepts, principles and rules of liquid-liquid extraction, leaching, crystallization, gas absorption and evaporation.
- Apply concepts and principles to calculate detailed engineering design of equipment's and instruments related to separation processes.
- Bridge between theoretical concepts with practical classes outcomes.
- Demonstrate skills and abilities needed to operate related chemical industries.

Contents: **No. of Classes**

Extraction: Characteristics of separation processes, Separation equilibria-one-component systems, two-component systems and three-component systems. Concept of ternary diagram, proportionality rules, distribution co-efficient, plait point, solutropy and capacity factors. Separation factor and its relationship to molecular properties. Selection of a separation process. Correlating equations: Bachman equation, Othmer - Tobias coordinates, Hand's equation, Trebal's plot etc. Graphic interpolation of tie lines. Distribution curves, power and selectivity of solvents. Solvent choice. **06**

Multistage Extraction: Classification, principles of cross-current extraction and counter-current extraction using one solvent. Multistage calculations. Mixers and settlers, packed tower, perforated plate column and rotating disc contactor for single solvent countercurrent extraction. Two-solvent counter current extraction, counter current extraction with reflux. **04**

Absorption and Desorption: Principles of absorption and desorption processes. General process design considerations. Operational and constructional features of absorbers and desorbers. Two-film theory, material balance for calculations of minimum liquid to gas ratio, determination of number of trays, Commercial absorption and desorption processes. **05**

Leaching: Definition, mechanism, Operating methods and equipment. Design calculation methods. Selection or design of a leaching process. Composition diagram. **04**

Crystallization: Industrial crystallization, significance of crystallization, relative super saturation, principle of cooling crystallization, crystal structure, factors affecting to deviate theoretical shape of crystal, entropic factor, particle size distribution, steps of crystallization, Theory of crystallization and crystallization equipments. Crystallization mathematical problems. **05**

Evaporation: Principles of Evaporation. Different types of Evaporators. Performance of tubular evaporators. Vapour recompression. **04**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Demonstrate knowledge of the various mass transfer operations such as gas absorption, liquid-liquid extraction, distillation, membrane separation, adsorption, leaching and washing, drying and crystallization;
- Use the phase equilibrium concepts in mass transfer related problems.
- Design staged /packed column for mass transfer operations.
- Solve problems related to adsorption.
- Solve problems related to liquid-liquid and solid-liquid extraction.

Reference Books:

- Alder, L., “Liquid-liquid extraction: theory and laboratory practice”, Elsevier Publishing Company.
- Treybal, R. E. “Mass Transfer Operations”, McGraw-Hill, Inc.
- McCabe, W. L., Smith J. C., and Harriot, P., “Unit Operations in Chemical Engineering”, McGraw-Hill, Inc.
- Badger, L. W. Banchero, T. J. Introduction to Chemical Engineering, McGraw Hill.
- Coulson, J. M., Richardson, J. F., “Chemical Engineering”, Volume 1 and 2, Pergamon Press.
- Foust, A. S. Wenzel, L. A., Clump, C. W., Naus, L., and Anderson, L. B., “Principles of Unit
- Operations”, John Wiley & Sons, Inc.

- Geankoplis, C. J., “Transport Processes and Unit Operations”, Prentice-Hall, Inc.

ACCE 3202: Material Science and Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course introduces Applied Chemistry and Chemical Engineering students (B.Sc.) to the field of material science and engineering. In this course students receive a set of formal lectures introducing them to the field of material science and engineering. This course includes selection of materials for modern engineering applications. Structure and properties of metals, ceramics, composites, polymers and nano-carbon compounds starting with fundamental atomic arrangements to the fundamentals of structures of crystalline solids.

Objectives:

- To introduce and provide a broad view of the engineering materials and their selection criteria for modern engineering applications.
- To introduce students to understand the fundamental structures of crystalline solids. Mathematics involves applied algebra and trigonometry, for example in solving exponential and logarithmic equations and in area, volume and density calculations.On another level of characterization, students will sketch three-dimensional cubic and hexagonal crystal structures found predominantly in metals.
- In depth study of structure and properties of metals, ceramics, composites, and polymersare emphasized.
- To introduce synthesis, characterization, properties and applications of carbon nano-materials.

Contents: **No. of Classes**

Engineering Materials: Materials classification, engineering requirements of materials, advanced materials and modern materials. Properties of Engineering Materials: Mechanical properties, factors affecting mechanical properties, physical, thermal, electrical, optical, magnetic and chemical properties of materials. Factors affecting the selection of materials for engineering purposes, materials selection and design considerations. **04**

Fundamentals of Structures of Crystalline Solids: Crystal structures, unit cells, crystal system, crystallographic points, directions and planes, single crystal, polycrystalline materials, anisotropy, non-crystalline solids. Metallic crystal structures (face-centered, body-centered, hexagonal close-packed and closed-packed crystal structures), crystal structures of closed pack anions, Imperfections in solids (vacancies and self-interestials), impurities in solids, imperfections in ceramics, interfacial defects, polymer defects. **04**

Mechanical Properties of Metals: Types of metals and alloys (ferrous, non-ferrous and thermal processing of metals), deformation (concept of stress-strain, plastic, elastic deformations and hardness), and failure of metals (fracture, fatigue and creep: types and principles). **04**

Polymers: Characteristics of polymers, different types of polymeric materials (plastics, elastomers and fibers). Mechanical behaviors of polymers, miscellaneous application of polymers. Thermoplastic and thermosetting materials, crystallization and melting, glass transition temperature, advanced polymeric materials. Deformation and fracture of polymers. Forming and Typical application of major elastomers and deformation of elastomers. **08**

Composite Materials and Ceramics: Classification of composite materials, fiber reinforced composites, hybrid composites, structural composites, reinforced concrete, polymer-matrix composites, metal-matrix composites, carbon-carbon composites, concrete polymer composites. Nature and types of ceramic products, comparison of ceramic and nonceramic phases, silicate structures, polymorphism and allotropy, application of ceramics, mechanical and glass properties of ceramics. **06**

Nano-Carbon Compounds: Fullerene [60], Fullerene [70], synthesis, separation and applications, carbon nano-tubes: properties, purification, characterization and application. **02**

Learning Outcomes:

Upon completion of the course, students will be able to:

- Select materials for design and construction.
- Perform a variety of calculations that pertain to properties of materials, primarily to metals and their alloys. (For example: Coordination number (CN). Atomic packing factor (APF). Density calculation and others).
- Sketch easy to visualize isometric or oblique pictorials of unit cells of common cubic metal crystal structures including: Body-centered cubic (BCC), Face-centered cubic (FCC), Simple cubic (SC), Crystallographic direction and planar (Miller) indices.
- Describe the structure-property relationship underlying the material science and engineering field of study and fundamentals of carbon nano-materials.
- Propose potential projects in material science and engineering.
- Design and conduct experiments, and to analyze data.

Reference Books:

- A Text Book of Material Sciences and Metallurgy by O. P. Khanna
- Materials Science and Engineering: An Introduction, by William D. Callister, Jr.

ACCE 3203: Corrosion Engineering **Credit: 3.0**
3 Hours/Week

Description:

The aim of this course is to provide basic knowledge of corrosion and its principle. The course gives adequate description of mechanism of different types of corrosion. In addition, on the basis of the knowledge of corrosion phenomena, this course also includes the methods, which are introduced to protect metals and alloys against corrosion.

Objectives:

- The main objective of this course is to introduce the students to the underlying science of corrosion engineering.
- To develop a sound understanding of corrosion theory and applications.
- To understand the basic types and mechanisms of corrosion.
- To understand what happens to metal during the reduction step of the oxidation-reduction process.
- To describe the effects of passivity and polarization on the corrosion process.
- To learn the engineering design of corrosion prevention systems.

Contents: **No. of Classes**

Corrosion: Corrosion, Classification, Corrosion Damage, Cost of Corrosion, Corrosion Engineering, Definition of Corrosion, Classification of Corrosion, Environments, Corrosion Damage, Future Outlook. **02**

Corrosion Principles: Introduction, Corrosion Rate Expressions. Electrochemical Aspects: Electrochemical Reactions, Polarization, Passivity. Environmental Effects: Effect of Oxygen and Oxidizers, Effect of Velocity, Effect of Temperature, Effect of Corrosive Concentration, Effect of Galvanic Coupling. Metallurgical and Other Aspects: Metallic Properties, Economic Considerations, Importance of Inspection, Study Sequence. **04**

Different Forms of Corrosion: Uniform Attack, galvanic or two-metal corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, fretting corrosion, stress corrosion, hydrogen damage. **08**

Corrosion under Various Conditions: Atmospheric corrosion, underground corrosion, immersion corrosion, marine corrosion, liquid metal corrosion. **03**

Corrosion Testing: Introduction, classification, purpose, materials and specimens, surface preparation, measuring and weighing, exposure techniques, duration planned-interval tests, aeration, cleaning specimens after exposure, temperature, standard expressions for corrosion rate, galvanic corrosion, high temperatures and pressures, different corrosion tests. **04**

Corrosion Prevention: Materials selection, alteration of environment, design, cathodic and anodic protection, coatings. **03**

Corrosion in Industries: Corrosion in boiler plant, chemical industries, petroleum industry, fertilizer industries. **04**

Learning Outcomes:

The course gives background for understanding various corrosion processes, protection methods and materials selection with practical examples. Based on the basic theory, the student shall learn to evaluate if corrosion can occur under specific operating conditions in a given equipment or construction. In cases where corrosion can occur, the student shall be able to determine the probable corrosion type, estimate the corrosion rate and propose the most reasonable protection method as regards safety, price and environmental considerations. The student shall be able to propose the correct materials, design and operation conditions to reduce the likelihood of corrosion in new equipment and constructions. The student shall also be able to propose necessary laboratory and field tests and take part in research programs to solve specific corrosion problems. The course also gives adequate engineering background for performing troubleshooting and corrosion monitoring. The course provides extensive teaching in corrosion theory and properties of important construction materials in the presence of corrosive environment.

Reference Books:

- Corrosion Engineering-Mars G. Fontana
- Corrosion engineering: an introductory text - Ahmed, Nooruddin; Mahmud, Iqbal
- An introduction to metallic corrosion - Ulick R. Evans

ACCE 3204: Metallurgy **Credit: 3.0**
3 Hours/Week

Description:

This course covers the extraction processes of ores, manufacturing of many materials, types, heat treatment etc. It also introduces the processing of materials to obtain the desired changes in its physical properties. Selective extraction of some economically valuable metals is also introduced in this course.

Objectives:

The main objective of this course is to understand, apply and correlate the knowledge and practical experience to understand many processes involved in metallurgy. At the end of this course students will be able to-

- Understand basic theories and mechanisms of metallurgical techniques.

- Correlate the techniques applied in industrial metal extraction processes.
- Gain experience in designing and construction of different grade of iron and steel.
- Develop methodologies for extraction of Uranium.
- Understand the processes of Pyro-metallurgy, Powder-metallurgy and Hydrometallurgy.
- Learn about different phases of metal upon alloying and heat treatments.

Contents:	**No. of Classes**
Metals and Ores: Occurrence and ore preparation. Physical methods of ore dressing: communication, sorting classifications, concentration, gravity concentration, forth flotation methods. Pyro-metallurgical techniques: calcining, roasting, sintering, smelting, reduction of ores with carbon and metals, thermal reduction process slag, fluxes.	**03**
Manufacture of Pig Iron: Raw material, blast furnace design and operation, chemical reaction in bose and hearth. By-products of the blast furnace and its utilization, heat recovery of blast furnace and its efficiency.	**03**
Production of steel: Cement steel, and crucible steel, the Bessemer process, the open hearth process, basic and acid production of steel in electric furnace. Duplex-process, deoxidation, alloying addition and steel ingots. Influence of minor elements in carbon steel, low steel and high alloy steel. Heat treatment of steel: annealing, normalizing, hardening, tempering, case hardening and gas carburizing.	**05**
Phase Diagrams: Definition and basic concepts, solubility limit, binary isomorphs system, development of microstructures in isomorphs alloys, binary eutectic system, and development of microstructures in eutectic alloys, iron-iron carbide phase diagram, and development of microstructure iron-iron carbide alloys.	**06**
Hydro-metallurgy: Principle of solvent extraction, leaching and their application in extraction of metals.	**02**
Powder Metallurgy: Principle, application, advantages and limitations. Characteristics and production of metal powders. Compacting, hot pressing and sintering.	**03**
Metallurgy of Aluminium: Principle involving in Aluminium extraction; Applications, properties, pnodization and Coloring.	**03**
Metallurgy of Uranium: Occurrences, geology of Uranium deposits, mining techniques; Uranium processing methods; Recovery of Uranium.	**03**

Learning Outcomes:

After the successful completion of this course students will be able to-

- Understand the science behind materials and many techniques in physical and chemical metallurgy.
- Analyze the structural properties, phase and phase diagrams.
- Differentiate many microstructures and classify different heat treated microstructures.
- Solve many mathematical problems related to many metallograhic procedure for given material.
- Investigate a suitable process for metal extraction based on the available facilities.

Reference Books:

- Industrial Chemistry (Part-I), R.K. Das
- Industrial Chemistry, B.K. Sharma
- Principles of Blast Furnace Iron making , Anil K. Biswas
- Materials Science and Engineering: An Introduction, WD Callister, Jr
- Introduction to physical metallurgy, SH Avner.
- Materials and Metallurgy, V.K Manchanda, G.B.S Narang
- Fundamentals of Powder Metallurgy , W. D. Jones
- Chemical Metallurgy :Principles and Practice, Chiranjib Kumar Gupta

ACCE 3205: Industrial Economics, Psychology and Management **Credit: 3.0**
3 Hours/Week

Description:

This course aims to facilitate students' understanding of economic aspects of industries, psychological impact in industrial environment and basic principles of management as well as its applications in industrial sectors. The course includes concepts, techniques and tools to analyze and understand cost estimation, profitability and depreciation of an established and new project. The fundamental knowledge required for determining the economic feasibility of a project, along with various techniques for developing conflict resolution skills are introduced in this course. It offers an overview of management theories and applications including supply chain management strategies and inventory management techniques.

Objectives:

- To familiarize students with different management principles.
- To help students develop an understanding of managerial functions, types, skills and roles.
- To introduce basics of supply chain management and different strategies employed in inventory management and production planning.

- To familiarize students with different concepts of economics.
- To introduce theories of motivation and systematic management of organizational conflict.

Contents:	**No. of Classes**
Cost Estimation: Factors affecting investment and production costs. Capital investments. Methods for estimating capital investment. Estimation of total production cost. Cost indexes. Estimation of Equipment costs by scaling. Simple and compound interest.	**04**
Taxes & Insurance: Taxes & Insurance	**03**
Depreciation: Physical & functional depreciations, methods for determining depreciation, evaluation of depreciation methods, service value, salvage value, present value and book value of an equipment.	**03**
Profitability, Alternative Investments & Replacements: Bases for evaluating project profitability, mathematical methods for profitability evaluation, determining acceptable returns, principles of alternative investments by different profitability methods, replacement policy, methods of profitability evaluation for replacements.	**05**
Price-cost Volume Relationship: Computation of break-even point, managerial use of breakeven analysis. Principal accounting tools/statements.	**03**
Principles of Management: Functions of management, management theories, and patterns of management.	**03**
Principles of Human Behavior: Motivation and theories of motivation, mechanisms of adjustment of conflict.	**03**
Supply Chain Management: Production planning and control, inventory management.	**04**

Learning Outcomes:

Specifically, by the end of the course students should be able to:

- Understand core concepts of management theories and get familiar with principles in management.
- Evaluate different organizational structures and roles of managers in a modern organization.
- Learn different economic concepts important for evaluating viability of a project.
- Define and evaluate different theories of motivation and mechanisms of conflict management.

- Distinguish different types of taxes and acquaint with various types of insurance requirements for a manufacturing concern.
- Understand core concepts of supply chain management and explore operations, production planning and inventory strategies employed in a sound supply chain system.

Reference Books:

- Plant Design and Economics for Chemical Engineers-Max S. Peters, Klaus D. Timmerhaus. Fourth Edition.
- CliffsQuickReview: Principles of Management- Ellen A. Benowitz
- Introduction to Operations and Supply Chain Management- Cecil C. Bozarth, Robert B. Handfield. Pearson Prentice Hall.
- Engineering Economy-William G. Sulivan, James A. Bontadelli, Elin M. Wicks, E. Paul Degarmo. Eleventh Edition
- Engineering Economy-Gerald J. Thuesen, W. J. Fabrycky. Ninth Edition
- Fundamentals of Engineering Economics-Chan S. Park
- Understanding Psychology-Feldsman

ACCE 3206: Polymer Analysis Sessional **Credit: 1.5**
3 Hours/Week

Description:

This course offers students to develop a practical knowledge about synthesis and analysis of various synthetic and natural polymers. Different analysis like moisture content, ash content, lignin content, total cellulose content of jute and different wood samples are carried out. Synthesis of some synthetic polymers like polyesters are performed along with the analysis of thermal and structural properties of these polymers. In this course, students are also introduced to different techniques to determine molecular weight of polymers.

Objectives:

The course is designed for students to:

- Obtain basic working knowledge required for the synthesis and analysis of polymers
- Gain knowledge about different methods of analysis.
- Familiarize with different properties of polymers like moisture content, ash content etc.
- Understand the difference between various synthesis methods of polymer.
- Understand the molecular weight and degree of polymerization and their effect on physical and chemical properties of polymers.
- Learn about safety measures needed in a polymer analysis laboratory.

Contents: **No. of Classes**

- Determination of moisture content of jute and different wood samples. **16**
- Determination of ash content of jute and different wood samples.
- Determination of lignin content of jute and different wood samples.
- Determination of holo cellulose content of jute and different wood samples.
- Determination of alpha cellulose content of jute and different wood samples.
- Analysis of saw dust: Estimation of total cellulose.
- Synthesis and analysis of a linear polyester.
- Synthesis and analysis of a cross-linked polyester.
- Determination of viscosity average molecular weight of polymers.

Learning Outcomes:

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

- Differentiate between qualitative and quantitative analysis of polymers.
- Explain different terms regarding physical and chemical properties of polymers.
- Explain the effect of structure of polymer on its thermal properties.
- Synthesize polymers by condensation reactions.
- Determine molecular weight of polymers.
- Explain and strictly adhere to the rules and safety regulations for work in the polymer analysis laboratory.

Reference Books:

- Sandler, S. R. (1998). Polymer synthesis and characterization: A laboratory manual. San Diego: Academic Press.
- Ashraf, S. M. (2008). A laboratory manual of polymers (Vol. 1). IK International Pvt Ltd.

ACCE 3207: Chemical Engineering Sessional - I **Credit: 1.5**
3 Hours/Week

Description:

This is a laboratory course work aiming to give students a firsthand experience on basic fluid mechanics and on some unit operations in chemical engineering principles. This course helps students understand the basic fluid mechanics topics discussed in theoretical classes such as Reynold's Number, Bernoulli's Theorem, etc. Also students are given to measure flow rates by different means i.e., rotameter, orifice meter, etc. This lab work also includes practical work on

different types of evaporation, liquid extraction, leaching, adsorption and different types of drying. This is the first chemical engineering related lab-work.

Objectives:

This course will help students to:

- Understand the basic theories of fluid mechanics through practical experience
- Acquire extensive knowledge and hands on training in different types of flow meter.
- Comprehend different types of Unit operations
- Able to solve practical engineering problems such as problems related to fluid flow, and their types, choosing drying methods, etc.

Contents: **No. of Classes**

- Study of various types of flows using Reynolds apparatus. **16**
- To determine the critical Reynolds number for transition from laminar to turbulent flow.
- Verification of Bernoulli's theorem.
- Flow through piping networks & frictional losses in pipe fittings and valves
- Viscosity Measurement
- Calibration of Venturi-meter
- Calibration of Orifice meter
- Open pan evaporation
- Single and multiple effect evaporation
- Experiments on liquid-liquid extraction
- Simple leaching
- Cross-current leaching
- Counter current leaching
- Ternary liquid equilibrium
- Adsorption isotherms.
- Atmospheric batch drying
- Packed absorption columns
- Continuous drying.

Learning Outcomes:

At the end of the course, learners will be able to:

- Understand the fundamentals of fluid mechanics more accurately
- Identify different fluid flow measuring devices and flow types
- Understand different unit operations and their principles
- Successfully apply the knowledge in real life engineering problems

Reference Books:

- Franzini, J.B, Finnemore, E.J. and Daugherty, R.L., 1997. Fluid Mechanics with engineering applications. McGraw-Hill College.
- Shames, J. H., "Mechanics of Fluid", McGraw-Hill. 1992.
- Coulson, J. M. and Richardson, J. F., "Chemical Engineering, Vol. I & II", Pergamon Press, Oxford, 1991.
- McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", McGraw-Hill, 2004.

ACCE 3208: Field Work **Credit: 1.5**

Description:

Industrial field work refers to work experience done during the program of study that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course student will visit at least two industries at the end of their second semester based on the availability of the industry located in the suitable area of the country. For the students of third year generally the field work session continued for three/four days by visiting any public or private chemical industry.

Objectives:

The fundamental objective of the field work is to prepare students for future employment in their chosen industrial discipline. Field work enhances the academic material studied in third year by allowing students to practice what they have learned and to develop key professional attributes by experiencing the theoretical knowledge into practical perspective. Field work should provide an opportunity for students to:

- Correlate the theoretical knowledge with practically observed chemical industry.
- Experience the discipline of working in a professional industry.
- Develop understanding of the functioning and organization of a chemical process industry.
- Interact with other professional and non-professional groups within the industry.
- Apply engineering methods such as design and problem solving.
- Develop technical, interpersonal and communication skills, both oral and written.

Learning Outcomes:

This course will offer a student to achieve ability to-

- Demonstrate the use of the product and the function of many types of equipment involved.
- Analyze a given engineering problem, identifies an appropriate problem solving methodology, implement the methodology and propose a meaningful solution.

- Apply prior acquired knowledge in theoretical problem solving session.
- Identify sources of hazards, and assess/identify appropriate health & safety measures.
- Work in a team.
- Take initiatives.
- Effectively communicate solution to problems (oral, visual, written).
- Manage a project within a given time frame.
- Adopt a factual approach to decision making.
- Take engineering decision.

Viva-Voce **Credit: 1.0**

At the end of the year (after completing the course work of all the semester) a student will sit for an oral examination. Members of the examination committee will evaluate the students by asking questions relevant to the courses of the current year. The teacher panel interviews the students on subjects studied year-long and measure their competency and understanding.

FOURTH YEAR

Semester - I

ACCE 4101: Chemical Engineering-V **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to introduce basic concepts and principles of heat transfer. The major topics discussed include basic equations for conduction, convection heat transfer and their applications in industrial processes. Different industrial handling and transportation techniques and equipment like pump, boiler, compressor, furnace, and boiler are discussed including their construction, advantages, and disadvantages. Finally, nuclear and thermal power plants are highlighted in this course to keep pace with the current trend happening worldwide.

Objectives:

The objectives of this course are to help students to understand basic concepts, ideas and problems associated with mass transfer operation and to find out their solutions. The completion of the course will enable students

- To understand basic theories and mechanisms of mass transfer

- To correlate the theories of heat transfer in many chemical industries.
- To gain experience in designing and construction details of heat exchanger.
- To develop techniques for handling and transportation of the fluids.
- To understand the function and operation of verities of pumps, boilers, compressors, furnace etc.
- To have a knowledge on the pump cavitation, positive displacement pumps etc.

Contents: **No. of Classes**

Basic Heat Transfer: Introduction and its applications, basic equations for conduction, convection heat transfer, principles of heat flow in fluids; radiation heat transfer, application of dimensional analysis to heat transfer, determination of heat transfer coefficient, Boundary layer heat transfer, **09**

Heat Transfer Equipment: Heat exchange equipment; design of different types of heat exchangers. **05**

Fluid Machines: Storage of liquids (carboy, drums, tanks). Basic classification of pumps. Theories, operation & design of pumps, compressors, turbines. Construction, advantages, disadvantages of mechanical pumps: centrifugal pumps-cavitations, NPSH, positive displacement pumps (rotary, piston, plunger, diaphragm pumps); basic characteristics curves for centrifugal pumps; fan, blower and compressor. **10**

Power Plant Equipment: Basic and fundamentals about thermal and nuclear power plants; equipment used in power plants; furnace, boilers. **04**

Learning Outcomes:

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

- Explain what heat transfer is.
- Identify mechanisms of heat transfer and calculate heat transfer rates.
- Formulate and solve different practical problems of heat transfer.
- Select appropriate equipment for handling and transport of a specific fluid.
- Identify the reason behind pump failure
- Draw the basic characteristics curves for centrifugal pumps; fan, blower and compressor.

Reference Books:

- Holoman, J.P., 2001.Heat transfer, Eight SI Metric Edition.
- McCabe, W. L., Smith J. C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw- Hill, Inc.
- Coulson, J. M. and Richardson, J. F., "Chemical Engineering, Volume I", Pergamon Press.

- Badger, L. W. Banchero, T. J. Introduction to Chemical Engineering, McGraw Hill.
- Plant Design & Economics for Chemical Engineers by Max Peters and Timmerhaus.
- Geankoplis, C. J., "Transport Processes and Unit Operations", Prentice-Hall Inc

ACCE 4102: Chemical Technology-IV **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to teach essential concepts and understanding related to surface chemistry, industrial production of leather and carbon with the emphasis on the role of agricultural chemical technology. Organic and inorganic fertilizers. Raw materials and their availability, fertilizers classification, types and application methods etc. are discussed. Fundamental of the types and manufacture of potassium fertilizers, manufacture and properties of complex fertilizers are also included in this course.

Objectives:

- Explain students to a practical exercise to produce leather by treating animal skins and hides
- Give a concrete idea about surface coating materials.
- To experience the importance and used of Potash and NPK fertilizer.
- Introduce the advantages of using herbicides, fungicides, insecticides, plant growth stimulator etc. Also give an idea about the disadvantages of using excessive of these chemicals.
- To acquaint with the importance of Carbon black, activated carbon, graphite, industrial diamonds etc.

Contents: **No. of Classes**

Leather Industries: Introduction-constituents of animal skin, preparing skins and hides, cleaning and soaking, liming and degreasing. Manufacture of leather: Leather tanning-vegetable tanning, chrome tanning and mineral tanning, dyeing and fat liquoring, leather finishing, oil tanning, by products. **06**

Surface Coatings: Objectives, methods and classification of surface coatings, preliminary treatment of surfaces. Paints and pigments-formulation, composition and related properties. Oil paint, vehicle, modified oils, pigments, toners and lakes pigments, fillers, thinners, enamels, emulsifying agents. Special paints (heat retardant, fire retardant, eco-friendly paint, plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless), metal spraying and anodizing. **05**

Potash Fertilizer: Importance of potassium fertilizers in agriculture, potassium status of Bangladesh soils, sources of potassium, production and use of muriate of potash and other potassium fertilizers. **05**

Complex Fertilizer: Ammonium phosphate sulphate, MAP/ DAP, nitrophosphates, urea-ammonium phosphates. Miscellaneous fertilizers: Biofertilizers, liquid fertilizers, controlled release fertilizer. **04**

Agrochemicals: Raw materials, method of manufacture and uses of insecticides, fungicides and Herbicides. **03**

Plant Growth Stimulators: types, preparation and application. **03**

Industrial Carbon: Carbon black, activated carbon, graphite, industrial diamonds. **02**

Learning Outcomes:

At the end of this course students will be able to-

- Understand basic manufacturing, tanning and finishing process of lather
- Differentiate between different tanning process, organic and inorganic fertilizer production methods etc.
- Understand the fundamentals of surface coatings and industrial carbon.
- Classify of fertilizers: solid, liquid, and suspension fertilizers.
- Analyze different types of potash and complex fertilizers etc.

Reference Books:

- Elementary Principles of Chemical Processes –Pelder & Rousseal.
- A Text book of Engineering Chemistry - M. M. Uppal.
- George T. Austin. "*Shreve's Chemical Process Industries*". 5th Edition, 1984, McGraw Hill.
- Industrial Chemistry, B. K. Sharma
- Industrial Chemistry-R. K. Das
- "Handbook of Fertilizer Technology", Fertilizer Association of India, New delhi.
- "Production of Fertilizers (Booklets 1 to 8)", European Fertilizer Manufacturers' Association.
- "Mineral Fertilizer Production and the Environment (Part 1 & 2)", International Fertilizer Industry Association.
- N. N. Melnikow: Chemistry of Pesticides (Springer).

- M. B. Green, G. S. Hartley West: Chemicals for crop protection and pest managements (pergamon).
- R. Cremlyn: Pesticides.

ACCE 4103: Polymer Science and Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course introduces Applied Chemistry and Chemical Engineering students (B. Sc) to the field of polymer science and engineering. This course is an introduction to the fundamentals of polymer science and engineering, covering the synthesis and characterisation of polymers, the relation between chemical structure and polymer morphology, mechanical, rheological, thermal and chemical properties and technological developments in commodity and advanced polymers. It also describes polymer molecular weight and weight determination techniques. Rubber and rubber compounding and different degradation mechanism of polymers are also discussed.

Objectives:

- To introduce the students to polymers, their synthesis, reaction mechanisms
- To provide an integrated view of polymer science and engineering, including the chemical structure of various polymers, methods of measuring the molecular weight, polymerization kinetics, rheological behavior, polymer processing technologies, and a variety of the engineering properties exhibited by polymers
- To provide the students with an understanding of characterisation techniques commonly used in polymerscience
- To provide the students with basic knowledge of the morphology of polymers in the solid state, amorphous and crystalline, and their thermal properties. Particular emphasis will be on the chemical structure of the polymer and its effect on themorphology.
- To introduce polymer technology including processing, applications and manufacturing
- To introduce rubber and rubber processing techniques
- To introduce polymer degradation mechanism and use of stabilizer to reduce degradation.
- To introduce about inorganic polymers

Contents: **No. of Classes**

Polymerization and Kinetics: Types of polymerization, addition polymerization (types and mechanism); free radical polymerization, different types of free radical initiators and their radical formation mechanism, radical inhibitors and their activity, condensation polymerization (types and mechanism); ring opening polymerization; copolymerization; **04**

polymerization by coordination catalyst. Kinetics of chain growth and step growth polymerization, anionic and cationic polymerization, derivation of copolymer equation.

Molecular Weight of Polymers: Weight average, number average molecular weight, sedimentation and viscosity average molecular weights, practical significance of molecular weights, and size of polymer molecules. Experimental methods for molecular weight determination; end group analysis, membrane osmometry, light scattering method, viscometry (Ostwald/digital viscometer) method, intrinsic viscosity, Mark Houwink equation, and gel permeation chromatographic technique. Polymer fractionation, fractional precipitation technique, extraction technique, gradient elution technique and molecular weight distribution curve **06**

Polymer Processing Techniques: Methods of polymerization, bulk, solution, suspension and emulsion polymerization. Fillers, plasticizers and softeners, lubricants and flow promoters, anti-aging additions, flame retarders, cross linking agents. Formation of flat sheets and films; laminations; foam formation; extrusion, injection molding, blow molding, compression and transfer molding; Spinning of fibers. **05**

Rubber: Natural rubber, synthetic rubbers, different types of rubber monomers, synthetic rubber polymerization, spectro-specific rubbers, rubber processing chemicals, rubber compounding, rubber fabrication, vulcanization, tire construction, reclaimed rubber, rubber derivatives, rubber industry in Bangladesh. Problems of rubber production and their solutions. **05**

Degradation of Polymers: Definition, types of degradation, causes of degradation, degradation mechanism of light, oxidation, thermal, mechanical and photo degradation and degradation stabilizers. **04**

Inorganic Polymers: Polymetallosiloxanes, introduction, synthetic methods for polymetallosiloxanes of Mg, Al, B, S and Ti. Metal chelate polymers: Introduction, Synthetic methods, Physical and Chemical Properties. **04**

Learning Outcomes:

Upon completion of the course, students will be able to:

- Understand the relationships between polymer molecular weight,molecular weight distribution, and the properties of polymeric materials.
- Demonstrate an ability to distinguish different polymerization reactions and their mechanisms/kinetics, and learn how actual polymerization is performed in the laboratory. Students will also be able to analyze polymerization data and predict the conversion and molecular weight, which willlead to critical thinking about how to improve the setup for better polymerization.

- Determine polymer molecular weights and molecular weight distributions from different types of experiments.
- Improve and expand their skills in performing and analyzing the thermal and mechanical properties of polymers, and demonstrate an ability to predict how the molecular weight willaffect these properties.
- Describe the rubber compounding and rubber processing techniques.
- Understand extrusion and injection mouldingprocesses.
- Understand how to reduce polymer degradations.

Reference Books:

- Fried, J. R., "Polymer Science and Technology", Prentice Hall, Inc.
- McCrum, N. G., Buckley, C.P. and Bucknall, C. B., "Principles of Polymer Engineering", Oxford University Press.
- Vasant R. Gowariker, Polymer Science".
- Tadmore, and Gogvs, C. G., "Principles of Polymer Processing" John Wily & Sons.
- Billmeyer, F. W., "Text Book of Polymer Science", John Wiley & Sons.

ACCE 4104: Spectroscopic Method of Analysis **Credit: 3.0**
3 Hours/Week

Description:

The course will introduce the students with the Basic Principles, Instrumentation, sample Handling and Spectral analysis of common analytical tools used in Chemical analysis.

Objectives:

The main objectives of the course are to provide:

- Basic knowledge of the theoretical background of both qualitative and quantitative measurement using spectroscopy and spectrometry.
- Comprehensive knowledge on how to handle samples and operate spectroscopic and spectrometric analysis.

Sufficient knowledge on data interpretation and spectral analysis for identification of chemical substances/species has been added here.

Contents:	**No. of Classes**
Ultraviolet (UV) and Visible Spectroscopy: Introduction; Nature of Electronic Excitations; Origin of UV Band Structure; Principles of Absorption Spectroscopy; Instrumentation; Chromophores; Effect of Conjugation; Woodward-Fieser Rules; Applications.	**05**

Infrared (IR) and Raman Spectroscopy: Introduction; Theory; Sample Handling; Experimental Technique; Modes of Stretching and Bending; Factors Affecting Group Frequencies; Correlation Charts and Tables; Applications.	**05**
Nuclear Magnetic Resonance (NMR) Spectroscopy: Introduction; Theory, Relaxation Processes; Shielding, Deshielding and Anisotropic Effects; Chemical Shift; Spin-Spin Splitting; First Order NMR Spectra; Applications	**07**
Mass Spectrometry (MS): Instrumentation and Sample Handling, Basic Aspects of Organic Analysis by MS; Resolution of a Mass Spectrometer; Fragmentation Patterns of various Classes of Organic Compounds; Working Principles of Quadruple Mass and Time-of-Flight Spectrometry.	**05**
Atomic Absorption Spectroscopy (AAS): Nature of Atomic Transitions; Grotrian Diagrams; Excitation Sources; Hollow Cathode Lamps: Constructions and Functioning Principles; Atomizers; Linewidth and Broadening; Interferences; Background Corrections; Analytical Applications.	**04**
Theory and application of fluorescence and phosphorescence spectroscopy, emission	**02**

Learning Outcomes:

After completion of the course the students will be able to:

- Explain basic principles, relevant terms, Instrumentation, Sample Handling, Operating Procedure of commonly used spectroscopic methods such as UV-Visible spectroscopy, Nuclear Magnetic Resonance (NMR), Infrared (IR) and Raman Spectroscopy, Fluorescence Spectroscopy, Mass Spectrometry and Atomic Absorption Spectroscopy (AAS).
- Interpret spectral data of UV-Visible spectroscopy, Nuclear Magnetic Resonance (NMR), Infrared (IR) and Raman Spectroscopy, Fluorescence Spectroscopy, Mass Spectrometry and Atomic Absorption Spectroscopy (AAS).
- Elucidate Structures of unknown/novel organic compounds using UV-Visible spectroscopy, Nuclear Magnetic Resonance (NMR), Infrared (IR) spectroscopy combined with Mass Spectrometry. Use of AAS for qualitative and qualitative analysis of toxic elements (As) and heavy metals in water and other samples. Use of Fluorescence spectroscopy to study photophysical properties of organic compounds and nanomaterials

Reference Books:

- Principles of Instrumental Analysis-Douglas A. Skoog; F. James Holler; Timothy A. Nieman

- Fundamentals of Analytical Chemistry- Skoog, Douglas A.; West, Donald M.; Holler, F. James
- Introduction to Spectroscopy - Donald L. Pavia; Gary M. Lampman; George S. Kriz
- Instrumental Methods of Chemical Analysis- B.K. Sharma
- Investigation of Molecular Structure- Bruce C. Gilbert
- Undergraduate Instrumental Analysis - James W. Robinson
- Exploring Chemical Analysis - Daniel C. Harris
- Introductory Raman Spectroscopy - John R. Ferraro; Kazuo Nakamoto; Chris W. Brown

ACCE 4105: Pharmaceutical Process and Technology **Credit: 3.0**
3 Hours/Week

Description:

This course covers the manufacturing processes and chemistry of tablets, capsules, emulsions, parenteral products, antibiotics, etc. The interaction of these materials with respective environment, storage procedures, types and method of administration are also highlighted in this course. Besides this procurement, good laboratory practice and prescription writing are introduced in different sections. Proper use of narcotics according to the prescription, drug abuse and other regulatory policies are also mentioned in different chapters.

Objectives:

The major objectives of this course are to -

- Understand the regulatory basics for process validation and outline the prospective validation.
- Differentiate the utility of different pharmaceutical dosage forms.
- Understand the GMP regulation regarding the utilities involved in pharmaceutical products manufacturing
- Learn the proper handling of prescription to avoid abuse of drugs.
- Understand the sterilization of parenteral products and other pharmaceutical dosages forms.
- Investigate the mechanism of action of the products at the different sites of action.
- Become familiar with the process of validation and quality assurance.

Contents: **No. of Classes**

Procurement, Specification, Storage and Dispensing of Pharmaceutical raw materials, API and excipients with examples and functions. Product development, Documentation and validation, responsibilities of QC and QA departments. **02**

Good Laboratory Practice (GLP), GMP, CGMP, Total Quality Management (TQM), Standard Operating Procedure (SOP), In Process Control of Pharmaceuticals Manufacturing (IPC), Techniques used in Pharmaceutical manufacturing. Reference standard and working standard & Calibration of instruments.	**03**
Tablet and Capsules: Functions of Excipients in tablet compaction, Manufacture by wet granulation, dry granulation and by direct compaction with comparison of the methods. Granulation and its importance. Machineries used in tablet manufacture, Common tableting problems and their remedies, Evaluation of tablets by measuring hardness, Weight variation, Friability, Disintegration time, Dissolution time etc. Classification of tablet coating, Different techniques of coating, Coating materials and equipment. Hard gelatin and soft gelatin capsules, Manufacture of gelatin shells, Manufacture of granules for capsules, Capsule filling machines, Tools, Problems in capsule manufacture, Packaging of capsules.	**07**
Parenteral Products: Definition, Types and Importance of parenteral products, Different air filtration units, Temperature, Pressure, Humidity control, Protocol for personnel and goods entry into the clean room, protective clothing, Routine monitoring tests, Sterilization and Validation, Formulation of parenteral products. Water for parenteral, Vehicles and additives, Containers, Manufacture, Quality Control (Pyrogen test, LAL test etc.).	**05**
Emulsion and Ointments: Definition of emulsion and ointments, classification of emulsions, Theory of emulsion formation, Function and classification of emulsifying agents, HLB values of emulsifying agents and its implication. Manufacture of emulsion including machinery required, Stability of emulsion, Factors affectingly absorption of ointment and emulsions by skin, Comparison of ointments with pastes and gels, Manufacture of ointments.	**05**
Antibiotics: Definition, Classification of bacterial strains, Classification of antibiotics, Production of 6-APA, Synthesis of -lactam and Chloramphenicol antibiotics. Mechanism of action and uses of different antibiotics, Emergence of resistant bacteria.	**04**
Code of ethics, Formularies and codexes officially recognized in Bangladesh, The prescription, proper handling of prescription, Prescriptions incompatibilities. Drug abuse, Narcotics Act, Drug Ordinance and related policies. Safety methods in pharmaceutical industry & waste disposal.	**02**

Learning Outcomes:

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

- Explain the different form of medication e.g., tablet, capsule, ointment, parenteral products etc.
- Illustrate the mechanism of the action of antibiotics, parenteral products etc.
- Explain the composition and method of formulation of different pharmaceutical dose forms with necessary equipment facilities.
- Learn many codes of ethics and formularies activated in our country and international world.
- Develop a concrete idea of good laboratory practice and procurement.
- Solve problems involving many pharmaceutical product formulations.

Reference Books:

- Operational principles for good pharmaceutical procurement- World Health Organization(WHO)
- Chapter 18: Managing Procurement - World Health Organization(WHO)
- Chemistry and Biology of B-lactam Antibiotics, Volume 1- Robert B. Morin, Marvin Gorman
- Pharmaceutical Manufacturing Handbook: Production and Processes (Shayne COX GAD)
- Parenteral Products, M. J Groves
- Pharmaceutical Capsules, Fridrun Podczeck and Brian E. Jones

ACCE 4106 :Chemical Engineering Sessional- II **Credit: 1.5**
3 Hours/Week

Description:

Chemical Engineering Sessional II includes practical lab work on identifying motor oil index, effect of additive on viscosity index, continuous and fractional distillation of binary mixtures, differential distillation, distillation with total reflux, centrifugal pumps and effect of head and flow on different set up of pumps, Heat transfer on different flow and particle size related experiments.

Objectives:

To help students

- Acquire extensive knowledge on different types of distillation, pumps and heat transfer equipment
- Comprehend the boiling and condensation studies
- Understand the characteristics curve of pumps and their practical applications

- Able to solve practical engineering problems such as problems related to heat transfer, effective pump selection, etc.

Contents: **No. of Classes**

- Determination of viscosity Index of Motor oils. **16**
- Continuous & Fractional distillation of binary mixtures.
- To determine the effect of polymeric additives on index viscosity.
- Centrifugal pump - (characteristic curves).
- Flow under varying head - (Equation of discharge).
- Boiling and Condensation Studies.
- Heat Transfer in Laminar Flow.
- Heat Transfer in Turbulent Flow.
- Simple distillation.
- Fractionation columns.
- Continuous Reactive Distillation.
- Distillation with Total Reflux.
- Differential Distillation.
- Particle size distribution of a mixture of particles by sieve analysis.
- Batch settling experiment.

Learning Outcomes:

At the end of the course, learners will be able to:

- Understand the fundamentals of distillation, heat transfer and particle size distribution more accurately
- Identify appropriate pump necessary for a process
- Understand how heat transfer is occurring at different flow types
- Understand the effects of Viscosity Index modifiers
- Successfully apply the knowledge in real life engineering problems.

Reference Books:

- Franzini, J.B, Finnemore, E.J. and Daugherty, R.L., 1997. Fluid Mechanics with engineering applications. McGraw-Hill College.
- Coulson, J. M. and Richardson, J. F., "Chemical Engineering, Vol. I & II", Pergamon Press, Oxford, 1991.
- McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", McGraw-Hill, 2004

ACCE 4107: Fuel & Petrochemical Engineering Sessional **Credit: 1.5**
3 Hours/Week

Description:

This course will help students to develop skills required to synthesize prominent petrochemical products. Students will get familiar with important lab techniques involved in petrochemical product synthesis. Different characterization techniques of fuel products are also introduced in this lab course.

Objectives:

- To determine flash point and fire point of lubricating oil samples with Pensky Marten's analyzer.
- To analyze calorific values of different fuel samples with Bomb calorimeter.
- To synthesize organic petrochemical products in the lab using important lab techniques.
- To get familiarize with lab techniques namely distillation, reflux, extraction and washing required in organic synthesis.
- To determine melting point of synthesized organic petrochemical products.

Contents	**No. of Classes**
• Determination of flash and fire point.	**16**
• Calorific value of Fuels by Bomb Calorimeter	
• Synthesis of phenol-formaldehyde resin.	
• Synthesis of terephthalic acid.	
• Synthesis of alkylbenzene.	
• Synthesis of cyclohexene by dehydration of cyclohexanol.	
• Synthesis of nitrobenzene	
• Synthesis of adipic acid.	
• Polymerisation of isobutylene.	

Learning Outcomes:

Students will be able to demonstrate difference between fuel and lubricating oil samples by determining flash point, fire point and calorific value. They will be able to show skills required to synthesize organic petrochemical products. They will be able to identify melting point of the synthesized products and investigate the purity of the products obtained.

Reference Books:

- J.N Harker and J.R. Backhurst, Fuel and Energy.
- Nelson, W.L., Petroleum refining engineering, McGraw-Hill Book Co

- G. D. Hobson and W. Pohl, Modern petroleum technology, 4th Edit., John Wiley & Sons, New York (1973). 996 pages

ACCE 4001: Project **Credit: 3.0**

Description:

In this course a student is given a research topic as project. Project work refers to theoretical experience acquired during the program of study that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course student will write a brief description on the topic according to the guideline provided by the project advisor. Based on the topic, the writing may cover up different sections and students will try to build up a scenario for Bangladesh. For the students of fourth year generally the project work session continued for two/three months.

Objectives:

The objectives of this course are-

- Understanding the nature of problem to be studied and identifying the related area of knowledge.
- Reviewing literature to understand how others have approached or dealt with the given topic.
- Collecting data in an organized and controlled manner so as to arrive at valid decisions.
- Analyzing data appropriate to the problem.
- Suggest a proper pathway to apply this knowledge for the advancement of the country.
- Drawing conclusions and making generalizations

Learning Outcomes:

On the successful completion of this course students will be able to-

- Articulate the given research problem and formulate a hypothesis
- Identify and demonstrate appropriate research methodologies and know when to use them
- Define, articulate and use terminology, concepts, and theory in their field
- Use library, website, article from reputed journal and other tools to search for existing body of research relevant to their topic
- Know existing body of research relevant to their topic and explain how their project fits
- Identify and practice project ethics and responsible conduct in research
- Solve problems, think critically and analytical reasoning as applied to scientific problems.
- Work collaboratively with other researchers, using listening and communication skills
- Work autonomously in an effective manner, setting and meeting deadlines
- Reflect on their own research, identifying lessons learned, strengths, and ways to improve

- Communicate confidently and constructively with other students and faculty as mentors
- Explain their project to others in the field and to broader audiences through presentations
- Articulate the relevance of their project to their coursework and professional future, synthesizing their research, academic, and professional interests and goals
- Design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

ACCE 4002: In plant Training **Credit: 3.0**

Description:

Industrial in plant training refers to work experience done during the program of study that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course student will visit at any industry at the end of their second semester based on the availability of the industry located in the suitable area of the country. For the students of fourth year generally the training session will continue for four weeks. In general, fertilizer industry, pulp and paper industry, pharmaceutical industry, natural gas field, glass industry, cement industry etc. are visited by the students.

Objectives:

The fundamental objective of the In plant training is to prepare students for future employment in their chosen industrial discipline. Industrial Training enhances the academic material studied in the department by allowing students to practice what they have learned and to develop key professional attributes by experiencing the theoretical knowledge into practical approach. Industrial training should provide an opportunity for students to:

- Correlate the theoretical knowledge with practically observed chemical industry.
- Experience the discipline of working in a professional industry.
- Develop understanding of the functioning and organization of a chemical process industry by working in different sectors like production unit, utility unit, maintenance section, power supply unit, fire and safety section, product distribution unit, quality control unit and so on.
- Interact with other professional and non-professional groups within the industry for a brief idea about the administrative procedure necessary for the proper functioning of the plant.
- Apply engineering methods such as design and problem solving.
- Develop technical, interpersonal and communication skills, both oral and written.

This training session also gives an opportunity to assess future employees. A demonstrated commitment and ability to take responsibility, make sound decisions, and apply technical skills

will be highly regarded. It gives students an opportunity to evaluate future employers as well as enabling informed decisions about the discipline and career paths to follow.

Learning Outcomes:

This course will offer a student to achieve ability to-

- Demonstrate the use of the product and the function of many types of equipment involved.
- Analyze a given engineering problem, identifies an appropriate problem solving methodology, implement the methodology and propose a meaningful solution.
- Apply prior acquired knowledge in theoretical problem solving session.
- Identify sources of hazards, and assess/identify appropriate health & safety measures.
- Work in a team.
- Take initiatives.
- Effectively communicate solution to problems (oral, visual, written).
- Manage a project within a given time frame.
- Adopt a factual approach to decision making.
- Take engineering decision

Semester - II

ACCE 4201: Chemical Technology-V **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to introduce various chemical industries in Bangladesh. Starting from raw material to packaging this course offers many important product based industry e.g., Pulp and Paper, Sugar, Adhesive, Wood chemicals, industrially important gases, cellulosic fibres etc. All of these are considered as very important material in many aspects. Raw materials, production, reaction. thermodynamics, equilibrium, kinetics, commercial processes to manufacture, construction of major equipments, technological developments etc. are the common topics highlighted for every product discussed in this course.This course also introduces a student to know about every possible problem encountered during the production of the materials.

Objectives:

This course is designed to-

- To provide the students the knowledge about the manufacturing of some important materials in industries of Bangladesh e.g., Pulp and Paper, Sugar as well as some wood chemicals and cellulosic fibers.

- To teach the advance technologies and methods involved in industrial manufacturing processes.
- To provide the broad aspect of raw material processing, chemical reactions and other process parameters as well as machineries and by products of the various industries.

Contents: **No. of Classes**

Sugar, Starch and Fermentation: Manufacture of sugar from sugar cane and sugar beet. Utilization of by products from sugar industry, miscellaneous sugars. Manufacture of starch, modification of starch, dextrin and dextrose, manufacture from corn, miscellaneous starches. Manufacture of industrial and absolute alcohols, rectified sprit, citric acid and vinegar. Sugar, starch and fermentation industries in Bangladesh. **05**

Adhesive: Introduction, classification of adhesives-adhesive Action-development of Adhesive Strength. Chemical factors influencing adhesive action bonding processes by adhesives-advantages and limitations-examples. Solvent responsive adhesives-uses of solvent responsive adhesives. Chemically reactive adhesives. Preparation of adhesives-Synthetic resin adhesives, Rubber based adhesives, Cellulose and silicate adhesives, Uses of adhesives. **05**

Pulp Manufacture: Structural and physical properties of pulpwood, chemistry of wood and fibers, preparation of pulpwood, manufacture of mechanical pulp, bleaching mechanical pulp, semi chemical, thermochemical and chemi-mechanical pulping, sulfite pulping, alkaline pulping, alkali recovery system, bleaching of wood pulps, treatment of pulp, new pulping processes, solvent pulping, rag pulping, dissolving pulp. **04**

Paper Technology: Stock preparation, production of paper, wet process, process instrumentation; waste solid and gas waste; Applied processes and techniques: Sizing, coating, dyeing, addition of chemicals, and calendaring; Fiber recovery, Broke system, Fourdriner machine, Jorden engine, dry process, coated papers, specialty papers, reuse of waste paper, structural board, Paper industry in Bangladesh. **04**

Cellulosic Fibers: Natural and synthetic fibers, rayon and acetate, viscose rayon, cellulose acetate, cuprammonium rayon, manufacture, properties and uses, packaging fines and rayon industry in Bangladesh. **04**

Wood Chemicals: Hardwood distillation, naval stores, gum oleoresins, terpentines, sulphate pulp rosin, tall oil, lignin, lignosulfates, hydrolysis of wood, wood extractives and conversion processes, wood distillation. **04**

Important Industrial Gases: Coke-oven gas, Producer gas, Water gas, Synthesis gas, Substituted natural gas, LPG, LNG etc. **02**

Learning Outcomes:

On successful completion of this course, students will be able to-

- Interpret and relate to the actual scenario of the technological processes.
- Apply the theoretical knowledge in the industrial training that is a part of their higher course and can also apply this knowledge during working practically in such industries.
- Develop the idea of manufacturing in large industries and the huge aspects related to it; i.e., from raw material availability to different use of the finished products and byproducts etc. Understand basic manufacturing and finishing process of the materials.

Reference Books:

- A Text book of Engineering Chemistry - M. M. Uppal.
- Shreve's Chemical Process Industries - Austin.
- Industrial Chemistry, B. K. Sharma
- Industrial Chemistry-R. K. Das

ACCE 4202: Instrumental Analysis **Credit: 3.0**
3 Hours/Week

Description:

The course will introduce the students with the Basic Principles, Instrumentation, Sample Handling and analysis ofvarious materials by using common analytical tools in chemical analysis i.e., Potentiometry, Electrogravimetry, Polarography, HPLC and analysis that involves X-ray (X-ray diffraction and X-ray fluorescence technique).

Objectives:

This course is designed to serve-

- Basic knowledge of the theoretical background of both qualitative and quantitative measurement using various techniques.
- Comprehensive knowledge on how to handle samples and operate instrument and perform analysis.
- Sufficient knowledge on data interpretation and analysis for identification of chemical substances/species.

Contents: **No. of Classes**

Electrogravimetry: Theory of electro-gravimetric analysis, Decomposition potential, electrode reaction, Effect of concentration electrode potential, Overpotential, completeness of deposition, Electrolytic deposition of metals, character of deposit. Electrolytic separation **05**

of metals with controlled cathode potential, Electrolytic determinations at constant current. Internal electrolysis.

Potentiometry: Introduction, reference electrodes, Indicator electrodes, Instrumentation and measurement of cell e.m.f., potentiometer and pH meter. Direct potentiometric titrations classical methods, Differential Potentiometric titrations, some experimental details for potentiometric titration **04**

Polarography: Basic principles. Direct current polarography: Residual current, Ilkovie equation, polarografic maxima, Half wave potentials, Equation of the polarografic wave. Quantitative Technique: general consideration, evaluation of quantitative results, measurement of wave heights. Equipment for polarography, dropping mercury electrode assembly. Voltametry: Cyclic voltametry, Anodic stripping voltametry. **04**

Amperometry: Amperometric titrations, Methodology, Advantages of amperometric titration, Technique of amperometric titrations with the dropping mercury electrode. Titration to zero current, Biamperometric titrations **04**

Coulometry: General discussion, fundamental principles, coulometry at controlled potential, the general technique. Coulometry at constant current: Coulometric titration: general discussion, the principle of coulometric titration instrumentation. **04**

X-Ray Methods: Introduction Production of X-rays and X-ray spectra. X-ray Methods and Applications: i) Direct X-ray methods, ii) X-ray absorption methods, iii) X-ray fluorescence methods iv) X-ray diffraction. **04**

High Performance Liquid Chromatography: HPLC Instrumentation, Basics of Separation, Mobile Phase Effects, The Role of the Column, Gradient Elution Technique, Normal and Reversed Phase Chromatography (i) Adsorption and Partition Chromatography (ii) Bonded Phased Packing (iii) Reversed Phase and Hydrophobic Interaction Chromatography, Ion Pair and Ion Suppression Chromatography, LC Detectors, HPLC Applications. **03**

Learning Outcomes:

After the successful completion of the course the students will be able to-

- Explain basic principles, relevant terms, Instrumentation, Sample Handling, Operating Procedure of commonly used instrumental techniques. such as HPLC, X-ray diffraction, X-ray Fluorescence,Coulometry, Amperometry, Polarography, Potentiometry, Electrogravimetry and so on.
- Interpret data of the sample obtained from the respective analysis.

- Elucidate Structures of unknown/novel compounds using these analytical methods and also determine the chemical composition, structure and bonding present in the unknown/known compound.

Reference Books:

- Undergraduate Instrumental Analysis- James W. Robinson.

ACCE 4203: Process Control **Credit: 3.0**
3 Hours/Week

Description:

This course involves the application of different techniques to design and operate dynamically consistent processes, tune and troubleshoot control loops, and make correct process control design decisions. Correct application of Process Control improves the profitability and safety of a given process, while maintaining high product quality standards.

Objectives:

- To introduce the key concepts in automatic control and instrumentation of process plants.
- To introduce students with Laplace Transformation as a means of conveniently representing process control systems and solving ordinary differential equations
- Solving first order, second order and integrating systems including dead time using basic controller algorithms.
- Describing and depicting commonly used sensing, transmission and final control elements in piping and Instrumentation Diagrams (P&IDs).
- To give knowledge about different types of controllers and their applications.
- To analyze different feedback control system and to know about their dynamic behavior and stability criterion.

Contents:	**No. of Classes**
Basic concepts of Chemical Process Control: incentives for process control; design aspects; hardware elements. Modeling for control purposes; development of mathematical models; linearization of nonlinear systems; input-output model; Transfer Functions. Standard process inputs; response of first and second order and integrating processes; Dynamic response characteristics- poles, zeros, transportation lag, Dynamic responses of interacting and non-interacting and MIMO processes.	**11**
Analysis and design of feedback control systems; feedback controllers and final control elements; Control system instrumentation; Dynamic behavior and stability of closed loop control systems; Controller Design, Tuning and Troubleshooting; Frequency response analysis; Bode diagram, Nyquist plots and their stability criteria; Analysis and	**11**

design of advanced control systems; control of system with large dead time or inverse response; multiple-loop control systems; feed forward and ratio control; adaptive and inferential control.

Design of control systems for multivariable processes: synthesis of alternative control configurations for MIMO; interaction and decoupling of control loops. Design of control systems for complete plants. **06**

Learning Outcomes:

On successful completion of this course students will be able to:

- Explain the basic principles & importance of process control in industrial process plants.
- Specify the required instrumentation and final elements to ensure that well-tuned control is achieved.
- Explain the use of block diagrams & the mathematical basis for the design of control systems.
- Design and tune process (PID) controllers.
- Develop mathematical models to describe the dynamic behavior of a process.
- Design control systems for a given process based on its dynamic behavior.
- Simulate and model control systems using SIMULINK software.
- Tune-up control systems using different tuning techniques.

Reference Books:

- Seborg, D.E., Edgar, T.F. and Mellichamp, D.A. (2003). "Process dynamics and control," Wiley, New York.
- Stephanopoulos, G. (1984). "Chemical process control: an introduction to theory and practice," Prentice-Hall, New Delhi.
- Smith, C.A. and Corripio, A.B. (1997). "Principles and practice of automatic process control," Wiley, New York.
- Johnson, C.D. (2006). "Process control instrumentation technology," Prentice-Hall, New Delhi.

ACCE 4204: Environmental Chemistry and Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course discusses on how the environment is interconnected to air, water, atmosphereetc. This course is consist of several topics including Atmosphere and its structure, Air pollution, Water pollution, Waste management, handling of hazardous waste etc.

Objectives:

This course offers to-

- Explain the interrelation between air, water and atmosphere
- Describe the causes of air and water pollution and also suggest many possible solution
- To study the possible sources of different wastes, conventional treatment of wastes and suggest an economically effect way to handle the waste smartly.
- Introduce the student with hazardous waste materials.

Contents:	**No. of Classes**
The Atmosphere and its Structure: Formation of particulates, ions and radicals in the atmosphere. Chemical and photochemical reactions in the atmosphere. Oxygen and ozone chemistry. Greenhouse effect. El Nino phenomena. Ozone hole.	**04**
Air Pollution: (a) Particulates: Natural and anthropogenic sources. Sinks and stokes Law. Effects and control of particulate emissions. (b) Gaseous pollutants. Sources, effects and control of: carbon monoxide, nitrogen oxides, hydrocarbons and photochemical oxidants, sulfur oxides.	**05**
Air Pollution: (a) Particulates: Natural and anthropogenic sources. Sinks and stokes Law. Effects and control of particulate emissions. (b) Gaseous pollutants. Sources, effects and control of: carbon monoxide, nitrogen oxides, hydrocarbons and photochemical oxidants, sulfur oxides.	**05**
Water Pollution: Introduction, aquatic environment, water pollutants, Organic pollutants (pesticides, organo-chlorine insecticides, organophosphates and carbamates, detergents, oil pollution, toxic organic chemicals), inorganic pollutants, sediments, radioactive materials, thermal pollution. Monitoring and control of water pollution: COD, and BOD.	**06**
Solid Wastes: Classification and origin, magnitude of the problem (Population × Affluence × Technology); characteristics of solid wastes; objectives and considerations in solid waste management; Methods of solid waste treatment and disposal (open dumping, compositing, sanitary landfill, incineration and pyrolysis; reclamation, recycle and reuse).	**04**
Hazardous wastes: nature and sources of hazardous waste; reduction, treatment, and disposal of hazardous waste (waste reduction and minimization, chemical treatment, preparation of wastes for disposal, ultimate disposal of wastes).	**03**

The State of the Global Environment; Earth summit, 1992; The Bangladesh Environment Conservation Act, 1995. **01**

Learning Outcomes:

After successful completion of this course student will be able to correlate the causes of environmental pollution through air and water. Students will participate in theoretical case study of the waste management and treatment and also suggest a proper way to solve that problem. They will be able to know the Bangladesh Environment Conservation Act.

Reference Books:

- Textbook of Environmental Chemistry and Pollution Control by S. Dara
- Environmental Chemistry by A.K.De
- Environmental Chemsitry by B.K.Sharma
- Environmental Pollution Control Engineering CS Rao
- Handbook of Industrial Pollution and Control by S.C.Bhatia
- Environmental Chemistry by JW Moore and EA Moore
- Bangladesh ECA 1995. (DoE)

ACCE 4205:Environmental Engineering Sessional **Credit: 1.5**
3 Hours/Week

Description:

To introduce students to how the common environmental experiments relating to air, water and wastewater quality are performed. This course will help students know which tests are appropriate for given environmental problems, statistically interpret laboratorial results and write technical reports, and apply the laboratorial results to problem identification, quantification, and basic environmental design and technical solutions.

Objectives:

Students who successfully complete this course will be able to:

- Perform common environmental experiments relating to air, water and wastewater quality, and know which tests are appropriate for given environmental problems.
- Compare between chemical and instrumental laboratorial results.
- Understand and use the water and wastewater sampling procedures and sample preservations. Obtain the necessary background for subsequent courses in environmental engineering. Demonstrate the ability to write clear technical laboratorial reports.
- Demonstrate the ability to work in groups.

- Understand the impact of water and wastewater treatment on people and the environment.

Contents: **No. of Classes**

- Determination of hardness of water. **16**
- Determination of DO, BOD and COD of wastewater sample.
- Determination of total nitrogen and ammoniacal nitrogen.
- Determination of TS, TDS, and TSS of a wastewater sample.
- Analysis of oil & grease in wastewater sample.
- Determination of fluoride, silica, sodium, calcium, potassium, magnesium, sulfide, sulfate, phosphate, nitrate, iron and heavy metals in water.
- Determination of pH of water.
- Determination of Turbidity of water.
- Determination of CO_2 content of water.
- Determination of Chloride of water.
- Determination of Arsenic concentration of water.
- Analysis of organic contaminants in water by spectroscopic method.
- Analysis of ambient air using high volume sampler.
- Removal of pollutants from industrial waste water

Learning Outcomes:

After successful completion of this course student will be able to evaluate the quality of water, air and waste water obtained from different sources. BOD, DO, COD, TDS, TS, TSS, Oil, Grease, Carbon dioxide content, Arsenic content etc. are determined by applying different chemical and analytical techniques.

Reference Books:

- Textbook of Environmental Chemistry and Pollution Control by S. Dara
- Environmental Chemsitry by B.K.Sharma
- Environmental Pollution Control Engineering CS Rao
- Handbook of Industrial Pollution and Control by S.C.Bhatia
- Environmental Chemistry by JW Moore and EA Moore

ACCE 4206: Computational Techniques in Chemical Engineering **Credit: 1.5**
3 Hours/Week

Description:

This course involves the help of computational techniques by using computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or

unsolvable by hand-calculations. This course is designed to give an overview of computational techniques of interest to process engineer. Understanding of computational techniques will be enhanced using several solved examples. This course introduces students to MATLAB programming and ASPEN HYSYS program, and demonstrate its use for scientific computations.

Objectives:

- To introduce the students to computational methods using MATLAB and Aspen HYSYS.
- To give students some understanding of how the algorithms work and to help them understand why numerical algorithms sometimes give unexpected results.
- The basic Aspen HYSYS part will show students how to model and simulate processes.
- To show students how analysis of unit operation will help them in order to optimize the chemical plant by using Aspen HYSYS.

Contents: **No. of Classes**

Aspen HYSYS: Introduction to Aspen HYSYS; Equations of State; Pumps Modeling, Setting up Compressors and Expanders; Setting up Flash Separator; Heat Exchanger Modeling; Conversion Reaction Modeling, Setting up CSTR; Distillation Column Modeling; Cost Optimization Using Aspen HYSYS . **16**

MATLAB: Introduction to MATLAB; Arithmatic Expressions; Mathematical functions; Logical Operators: Relational Operators: Matrices; Working with polynomials (manipulating polynomials, derivatives roots, eigen values); Linear Equations; Graphs: 2-D and 3-D plots, Log-log and semi-log plots; Histograms; Writing in an m-file, function calling in MATLAB; Functions in MATLAB (with examples); if , else, else if, while, for, switch, break; Numerical Analysis using MATLAB: Bisection method, Regula-falsi method, Newton Raphson method.

Learning Outcomes:

On successful completion of this course students will be able to:

- Learn basics of MATLAB programming.
- Create and format MATLAB graphics, write and run MATLAB scripts, including those that involve for loops, while loops and conditional branching.
- Get introduced to numerical methods for engineering problems.
- Will be able to use MATLAB to solve computational problems.
- Setup a simulation, run it, get results and more important, analysis of the process for further optimization.
- Rapidly construct flow sheets using the intuitive, user-friendly features and bi-directional calculations of Aspen HYSYS.
- Evaluate the performance of existing equipment with the Rating function.

Reference Books:

- Beers, K.J., 2006. *Numerical methods for chemical engineering: applications in Matlab*. Cambridge University Press.
- Hanyak, M.E., 2012. *Chemical process simulation and the Aspen HYSYS software*. Department of Chemical Engineering, Bucknell University.

Viva-Voce **Credit: 1.0**

At the end of the year (after completing the course work of all the semester) a student will sit for an oral examination. Members of the examination committee will evaluate the students by asking questions relevant to the courses of the current year. The teacher panel interviews the students on subjects studied year-long and measure their competency and understanding.

THE END