Course Curriculum for Master of Science (MS)
Department of Applied Chemistry and Chemical Engineering (ACCE)
University of Dhaka, Dhaka-1000, Bangladesh.

Master of Science (MS) in **Applied Chemistry and Chemical Engineering** from the session 2020-2021 to onward.

1. Graduation Criteria

1.1. Name of Degree: M.S. in Applied Chemistry and Chemical Engineering.

1.2. Entrance qualification: 4 years B.Sc. Honors degree in Applied Chemistry and Chemical Engineering with minimum CGPA of 2.5 in the scale of 4. A student must have to admit within the 3 academic years after obtaining honors degree. A student can enroll either in non-thesis or in thesis group.

1.3. Total Credits: The courses will consist of 27 credits of theory, 08 credits of Thesis (for thesis group only)/Laboratory Work (for non-thesis group only), 3 credits of industrial training (4 Weeks Industrial Training) and 2 credits of viva-voce. The total number of courses shall be of 40 credits.

1.4. Total Years: The courses of study for the M.S. degree shall be extended over a period of 1.5 (one and half) academic years with 2 semesters per year i.e. total 3 semesters. 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 3 semesters (1.5 years): 40.0

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 M.S. in Applied Chemistry and Chemical Engineering are 40.

Teaching of the courses:

- ✓ One hour per week is assigned for each credit of a theory course.
- ✓ Total Contact Hours in a semester for each 1.0 credit theory course: 14×1=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: 14×2=28.

2. Examination System

A student will be evaluated continuously in the semester system, for theoretical classes s/he will be assessed by class attendance, mid-term assessment and final examination. For laboratory work, a student will be assessed by class attendance, observation of his performance at work, viva-voce during laboratory work, evaluation of laboratory reports and practical examination. Thesis student will have to give a presentation and producing a thesis report to the examination committee. Industrial training is evaluated based on submission of a report, by a written examination and viva-voce.

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 thesis:

i. Presentation	40%
ii. Report	60%

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 courses 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

3.1.1. 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.

3.1.2. F Grades: A student obtaining 'F' grade in one or more courses will not be awarded degree. However, a student obtaining 'F' grade in a course may be allowed to retake that course only once with the next immediate batch. However, the grade can be improved to B+ at best in applicable case. A student obtaining 'F' grades in more than one course will not be allowed to repeat any course.

4. Improvement:

If a student obtains a grade 'C+' or lower in a course in any year, he/she will be allowed to repeat the course final examination only once 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. A student will be allowed to take improvement of 25% of the total theoretical credits taken. There will be no improvement examination for practical, viva-voice, in-course and industrial training written.

5. Readmission:

A student failing to complete the MS course in a year may seek readmission with the next available batch, provided s/he applies within one month of publication of the result of the concerned year.

A readmitted student will be allowed to retain his/her in-course and class assessment marks in previous year.

A readmitted student may be allowed to take up thesis work as decided by the department academic committee. The transcripts of successful readmitted student will bear the letter 'R' after GPA with a footnote explaining 'R' means Readmission.

5.1. Requirements for M.S. degree in ACCE:

A minimum GPA of 2.50 on a scale of 4.00 must be obtained in order to be awarded the M.S.

Semester-wise List of Courses

Semester-I

Course Code	Course Title	Credit
ACCE-5101	Chemical Engineering	**3.0**
ACCE-5102	Energy Conversion Engineering and Environment	**3.0**
ACCE-5103	Advanced Chemical Engineering Kinetics & Reactor Design	**3.0**
ACCE-5104	Advanced Polymer Sciences and Biomaterials	**3.0**
ACCE-5105	Food Processing Engineering and Technology	**3.0**
Total Credits		**15.0**

Semester-II

Course Code	Course Title	Credit
ACCE-5201	Textile Fibers and Dyeing Technology	**3.0**
ACCE-5202	Nanoscience and Nanotechnology	**3.0**
ACCE-5203	Biochemical Engineering	**3.0**
ACCE-5204	Environmental Pollution and Industrial Waste Management	**3.0**
ACCE-5205	Industrial Training	**3.0**
	Viva Voce	**2.0**
Total Credits		**17.0**

Semester-III

Course Code	Course Title	Credit
ACCE-5000	Applied Chemistry and Chemical Engineering Sessional /Thesis	**8.0**
Total Credits		**8.0**
Grand Total		**40.0**

Semester – I

ACCE 5101: Chemical Engineering **Credit: 3.0**
3 Hours/Week

Description:

The discipline and practice of Chemical Engineering is currently undergoing profound changes, which will have an important impact on the need for advanced training. The target of this course is to provide knowledge of principles of different stage processes such as distillation, extraction and absorption. This course also includes graphical methods and other short cut methods to calculate stages of different separation processes.

Objectives:

- To provide students with advanced skills in Chemical Engineering.
- Understanding of chemical engineering unit operations including different separation processes.
- To adapt readily to the challenges presented in a diverse range of industrial sectors that can benefit from process engineering approaches.
- Ability to define engineering problems, explores solutions, and critically analyzes to achieve a practical solution.
- To provide chemical engineering students with a strong technical education and communication skills that will enable them to have successful careers in a wide range of industrial and professional environments.

Contents: **No. of Classes**

Equilibrium Stage Operations: Principles of stage processes; calculation of stages by graphical methods and other short cut methods using Fenske, Underwood, Colburn and Gilliland correlation; binary distillation, x-y diagrams; multicomponent distillation-phase equilibria and concept of key components, pinch point etc.; calculation of multicomponent system; design calculations, theoretical analysis. Azeotropic and extractive distillation. Distillation equipments; Plate and packed towers. Design procedures. **14**

Multistage Counter Current Gas Absorption: Calculation of theoretical stages in absorption column; graphical design procedure; multicomponent absorber and stripper; absorption in single equilibrium stage; continuous differential-contact packed column design. **06**

Equilibrium in Ternary System: Equilateral triangular coordinates and rectangular coordinates; liquid-liquid extraction calculations-solvent free basis; system of three **04**

liquids- one pair partially soluble/two pairs partially soluble; continuous countercurrent extraction with reflux; multicomponent system.

Continuous Contact Mass Transfer Equipment: Packed and spray columns and other special designed columns; gas absorption in packed column; continuous liquid-liquid extraction columns. **04**

Learning Outcomes:

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

- Design systems, components, and processes to meet desired needs applicable to chemical engineering.
- Identify, formulate, and solve chemical engineering related problems.
- Use the techniques, skills, and modern engineering tools necessary for chemical engineering practice.
- Achieve knowledge of contemporary chemical engineering related issues.

Reference Books:

- Treybal R.E., Mass Transfer Operations, McGraw Hill
- McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
- Seader J.D. & Henley E.J Separation Process Principles Wiley India
- Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon
- Foust A.S. et al, Principles of Unit Operations, John Wiley
- C. D. Holland: Multi-component distillation.
- M. Van Vincle : Distillation.
- B.D. Smith: Design of Equilibrium Stage Processes.
- H. Sawistowski and W. Smith: Mass Transfer Process Calculations.
- Sherwood, Pigford and Wilke: Mass Transfer.

ACCE 5102: Energy Conversion Engineering and Environment **Credit: 3.0**
3 Hours/Week

Description:

This course is designed to introduce various forms of energy like conventional fuels (i.e., Natural gas, Petroleum, Coal, CNG, LNG, and LPG etc. with their advanced processing technology), and renewable energy; solar energy, wind energy, biofuels, hydrogen energy and nuclear energy. It also includes basic concepts and principles of energy conversion into more convenient form for the users. Different techniques for capturing greenhouse gas like carbon dioxide are also discussed

in this course. As well as the causes of climate change due to the excessive use of conventional fuels and the effects on the environment is discussed in this course. Possible solutions for the extreme global warming are also highlighted.

Objectives:

This program focuses on fundamental and applied aspects of energy policy, energy engineering including aspects of energy conversion, climate change and renewable energies. It integrates the latest scientific developments and methods which are highly applied in nature. The program fosters system and process-orientation and interdisciplinary thinking among students focusing on the followings:

- To acquire a respectable background in the various energy technologies to attain the energy policy objectives of Bangladesh.
- To understand technologies for sustainable energy production, conversion and utilization.
- To impart knowledge on advanced and clean fossil fuel conversion technologies in mitigating climate change.
- To impart an understanding of the potential, challenges and opportunities, amongst the students, regarding the rapid global integration of renewable energy systems into the energy mix.
- To enable the students to grasp the basic technical concepts related to each of the major renewable energy harnessing method.
- To generate awareness amongst the students regarding the local and global environmental degradation due to increasing global population and standards of living, with particular reference to Bangladesh, and their mitigation through adopting the renewable energy options.
- To satisfy the growing market demand for skilled manpower in the new, clean and economical energy sources.

Contents:	**No. of Classes**
Introduction to Energy Conversion: Energy outlook of Bangladesh: present and future energy demand and supply; potential reserve; energy policy of Bangladesh.	**01**
Natural Gas: Introduction, Natural Gas conversion technologies and effective utilization of natural gas in Bangladesh, CNG, LNG and LPG technologies.	**04**
Petroleum: Advanced knowledge on petroleum conversion processes, Lubricating oil preparation technology, Visbreaking and Hydrocracking.	**03**
Coal: Coal fields in Bangladesh and their characterization. Coal conversion and clean fuel from coal. Underground Coal Gasification (UCG).	**03**

Climate Change, Global Warming and Carbon Dioxide Capture and Sequestration (CCS): Causes & Impacts of Climate Change and Global Warming; Paris climate agreement (COP21); Global warming and fossil fuel; Future energy options. Overview of CCS strategies and technologies; Current status of CCS, CO_2 capture from power plants (Pre-, post-, oxyfuel- and chemical looping combustion); Industrial application of CCS technologies. **04**

Nuclear Energy: Nuclear processes; neutron interactions: scattering, absorption, fission; thermal & fast neutrons; reactor components; classification of reactors; nuclear fuel cycle: enrichment, fabrication, reprocessing; importance of heavy water; waste disposal; basic requirements for nuclear fusion; possible routes to fusion power; fusion hybrid; cold fusion; objectives of R&D in nuclear energy. **03**

Solar Energy: Solar radiation and its measurement; solar collectors; solar thermal energy storage systems; solar water heating; solar space heating & cooling; solar distillation; solar pumping; solar cooking; solar greenhouses, solar production of hydrogen; solar photovoltaic (PV) system; efficiency of solar cells; semiconductor materials for solar cells; applications of PV system; PV hybrid system. **03**

Biomass Energy and Biofuels: Biomass energy conversion technologies; Biomass gasification; Liquid bio-fuel production (bio-diesel, bio-oil and bio-ethanol production) technology; bio-char. Bio-refineries and their future prospects; Energy recovery from urban waste; Power generation from waste. **03**

Wind Energy: Basic principles of wind energy conversion; wind energy conversion systems (WECS); types of wind machines and their characteristics; horizontal and vertical axis wind mills; coefficient of performance of a wind mill rotor; aerodynamic considerations in wind mill design; site selection considerations of a wind mill; wind energy farms; applications of wind energy; safety and environmental aspects. **02**

Hydrogen Energy: Introduction; production methods of hydrogen; hydrogen storage; hydrogen transportation; utilization of hydrogen; hydrogen as an alternative fuel for motor vehicles. **02**

Learning Outcomes:

- Obtaining a good overview of the various energy conversion processes with their environmental impacts.
- Obtaining of understanding of the basic principles of the extraction of various energy resources.
- Graduates will be able to apply the knowledge and principles of energy engineering and use appropriate technologies for the betterment of the society.

- Recognize international and national issues related to global warming and environmental degradation, in respect of energy generation and consumption.
- Solve problems by thinking critically, creatively and reflectively and disseminate solutions in an effective manner.
- Apply the science and engineering principles for solving the energy related issues specific to Bangladesh and other developing countries.
- Select and apply appropriate techniques, resources and modern engineering tools, including prediction and modeling, to design, analyze and experimentally verify the renewable energy systems and their components output.
- Understand the impact of renewable energy solutions in societal and environmental contexts and demonstrate knowledge that is necessary for sustainable development

Reference Books:

- Energy Resources of Bangladesh - Badrul Imam
- Non-Conventional Energy Sources - G. D. Rai
- Solar Power Engineering - B. S. Magal
- Power Plant Engineering - G. R. Nagpal
- Fuel and Energy - J. H. Harker and J. R. Backhurst
- Handbook on Energy and Climate Change - Roger Fouquet
- Energy, Environment, and Climate - Richard Wolfson
- Climate Change and Global Energy Security - Benjamin K. Sovacool and Marilyn A. Brown
- Global Warming and Climate Change - S. K. Agarwal
- Impact of Climate Change on Socio-economic Conditions of Bangladesh – Anwar Zahid, Muhammad Qumrul Hassan, Quazi Abdus Amad, Rafiqul Islam, Mohammad Salim Khan, and Rojibul Haque.

ACCE 5103: Advanced Chemical Engineering Kinetics and Reactor Design **Credit: 3.0**
3 Hours/Week

Description:

This course is divided into two parts, one is reaction kinetics, and another one is reactor design. In reaction kinetics part the course includes kinetics of homogeneous, heterogeneous and homogeneous complex reaction. Different types of reaction and derivation of their rate expression data are also included. In reactor design part, the course includes different types of reactor design for different types of reactions like single and multiple reactions. The course also includes design, analysis and optimization of industrial problems.

Objectives:

- To provide the students the knowledge of the reaction mechanism, rate and kinetics of homogeneous, heterogeneous and complex reactions.
- To enhance the students understanding on chemicals reactors, their design and working principles.
- To improve the design and analysis capability on various mathematical models for chemical reactors and reactions.
- To learn the advance techniques of materials and catalysts characterization.

Contents:	**No. of Classes**
Kinetics of Homogeneous Reactions: Variables affecting rate, elementary and nonelementary reactions; active intermediates; pseudo-steady-state hypothesis; rules of thumb for development of mechanism; kinetic models; hydrogen bromide reaction; interpretation of reactor data; deducing the rate laws from the experimental observations and the model of reaction. Homogeneous catalytic reactions; Chain reactions; Series, parallel and series, parallel reactions; enzymatic reactions.	**05**
Kinetics of Heterogeneous Reactions: Introduction to catalytic and non-catalytic reactions; steps in a catalytic reaction; adsorption isotherms, surface reaction and desorption; classical work of Ward and testing of models; determination of a rate law, model of reaction and rate-limiting step; experimental reactors and treatment of data; design of moving bed, packed bed and fluidized bed reactors and reactors for uncatalysed heterogeneous reactions.	**05**
Kinetics of Homogenous Complex Reaction: Kinetics of Fluid-solid and fluid-fluid catalytic and non-catalytic reactions; Two film theory for gas-liquid mass transfer; Rate equation for straight mass transfer; Fluid solid reaction modeling – PCM and SCM model. Design of stirred reactors; Bubble column reactors, Slurry reactors, adiabatic and programmed reactors. Catalysis and adsorption; Catalyst preparation and characterization: Surface area and pore size distribution; Introduction to other characterization techniques (XRD, electron spectroscopy, thermal analysis, TPR, TPO, TPD; desorption spectroscopy, SEM)	**05**
Design for Single Reactions: Batch, plug flow and CSTR reactors; Size comparison of single reactors; Rate and performance study of the reactors; Space time and space velocity.	**03**
Design for Multiple Reactions: Treatment of multiple reactions; maximizing the desired product in parallel reactions, series reactions, series-parallel reactions; net reaction rates	**05**

and stoichiometry; multiple reactions in a plug flow reactor, in a CSTR. Holding time and Residence time distribution (RTD), Product distribution and contacting pattern.

Design and Analysis of Industrial Experiments: Optimization; development of mathematical models. Modeling of Multi-phase Reactors; Dynamic behavior of chemical reactors, Reactor optimization and scale up. Unsteady state operation of reactors: Start-up of a mixed flow reactor, Semi-batch reactor; non-isothermal batch, mixed flow and plug flow reactors. **05**

Learning Outcomes:

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

- Interpret and analysis of chemical reactions kinetic data.
- Apply reaction kinetics principles in chemical and biochemical reaction engineering.
- Selection and design of various chemical and biochemical reactors.
- Develop the ability to apply various mathematical models for chemical reactions.
- Explain and apply the principles of various characterization techniques for catalysts, reactant and products.

Reference Books:

- Levenspiel O., Chemical Reaction Engineering, John Wiley
- Fogler H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India
- Smith J.M., Chemical Engineering Kinetics, McGraw Hill
- Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

ACCE 5104: Advanced Polymer Sciences and Biomaterials **Credit: 3.0**
3 Hours/Week

Description:

This course offers an advanced level study of polymer science and engineering, covering the controlled radical polymerization technique, characterization of polymers, relation between chemical structure and polymer morphology; mechanical, rheological, thermal and chemical properties and technological developments in commodity of advanced polymers.

Objectives:

The course objectives are:

- To introduce the students to polymers, their synthesis, reaction mechanism and kinetics.

- To provide the students with an understanding of polymer behavior in the solid and solution state; as well as characterization techniques commonly used in polymer science
- To provide the students with basic knowledge of the morphology of polymers in the solid state as well as amorphous and crystalline phase; and their thermal properties. Particular emphasis will be given on the chemical structure of the polymer and its effect on the morphology.
- To teach the students the concepts related to mechanical/viscoelastic, chemical, electrical and optical properties of polymers.

Contents: **No. of Classes**

Polymer Solution: Factors affecting polymer solubility, orientation treatment, solubility of polymers, glass transition temperature, polymer degradation, effect of reinforcement on the properties. Criteria for polymer solubility, solubility parameter, and thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory-Huggins theory, Lower and Upper critical solution temperatures. **05**

Structure and Properties of Polymer: Morphology in crystalline polymers; polymeric liquids, state of polymeric liquids, rheology & the mechanical properties of polymers; soft matter, complex fluids, relaxation time, dimensionless numbers, theta temperature, viscoelasticity, creep and stress relaxation, viscoelastic properties of amorphous polymer, Hooke's law, Maxwell model, Voigt model, maxwell-weichert model. Configurations of polymer chains, order in crystalline polymers, crystal structure of polymers, crystallization and melting. Polymer structure and physical properties- crystalline melting point, melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. **08**

Controlled Polymer Structures: General background, controlled radical and living radical polymerization (ATRP and RAFT), mechanism of atom transfer radical polymerization (ATRP) and radical addition fragmentation transfer (RAFT) and surface initiated radical polymerization, click reaction in polymer science, graft and block copolymers and polymer self-assembly. **06**

Analysis and Testing of Polymers: Chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, microscopy. Thermal analysis and physical testing-tensile strength. Fatigue, impact, and tear resistance, hardness and abrasion resistance. **06**

Polymers in Tissue Replacement: Hard tissue; orthopedic implants (hip, knee), dental implants. Soft tissue; skin implant, burn (wound), dressings/ synthetic skin, dialysis membranes, scaffolds, vascular implants, heart valve implants, artificial kidneys and livers. Biomaterials for gene delivery. Hydrogel as stimuli-sensitive biomaterials, ophthalmologic implants, biomaterials for drug delivery. Blood and tissue compatibility **03**

of biomaterials and their in vitro and in vivo assessment. Mineralization and encrustation, microbial, biofilm formation, bacterial adhesion toxicology, degradation of biomaterials in biological environments, toxicity of biomaterials, acute and chronic toxicity studies.

Learning Outcomes:

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

- Learn about different polymers and their solubility, degradation and reaction profiles.
- Investigate the properties of polymer by applying many analytical techniques.
- Explain the polymerization techniques.
- Investigate and develop suitable polymer in many in vivo and in vitro application starting from human gene to tissue replacement.

Reference Books:

- Billmeyer F.W., Text book of Polymer Science, John Wiley.
- Gowariker V.R., Polymer Science, New Age.
- Shah V.H., Handbook of Plastic Testing Technology
- Rodrigues F., Principles of Polymer Systems, Tata McGraw Hill
- Premamoy Ghosh., Polymer Science and Technology, Tata McGraw Hill.
- Ratner, Hoffman,Schoen Biomaterial science- an introduction to materials in medicine Academic press
- Park .J.B. Biomaterials- science and engineering, Plenum press
- Sharma C.P., Szycher.M Blood compatible materials and devices Technomic publishing company
- R.M. Johnson, R.M. Mwaikambo, Tucker Biopolymers Rapra Technology

ACCE 5105: Food Processing Engineering and Technology **Credit: 3.0**
3 Hours/Week

Description:

Foods are the source of basic nutrients that an animal body requires to construct its structure as well as to perform its metabolic functions. To acquire extensive knowledge about the basic nutrients' sources, nutritive aspects, standards, preservation process/operation, their quality assurance techniques are major topics to be discussedin this course. Moreover, diversified food preparation and their waste management are also widely manifested.

Objectives:

The objectives of this course is to:

- Distinguish the nutritive values of various food items which are very essential for human body.
- Learn the standards to be maintained during the processing of food materials.
- Know how the food product deteriorates and how to preserve food to enhance the shelf life.
- Know the basic preservation techniques utilized for the food material in the industries as well as in the domestic purpose.
- Differentiate the merits and demerits of various preservation techniques.
- Know especially how the confectionery and the bakery items are prepared and preserved.
- Learn the preparation techniques of chocolate products in detail in the industries.
- Familiar the preservation techniques of various cereal grains and vegetables.
- Learn how milk as raw material undergoes various degrees of preparations for production of finished dairy products.
- Know how the alcoholic beverages are prepared from diversified raw materials.
- Distinguish various techniques of meat, poultry and fish preservation.
- Discover how the food processing wastes can be disposed maintaining the proper approaches.
- Determine the various nutritive aspects of food materials qualitatively and quantitatively through laboratory methodologies.
- Know about the food adulterants commonly used for the manipulation of food products and how they can be detected.
- Learn how the raw materials can be contaminated through fertilizer and pesticides during cultivation and how they can be distinguished using laboratory techniques.

Contents:	**No. of Classes**
Introduction: General aspects of food industry, world food needs and Bangladesh situation, constituents of food, quality and nutritive aspects, food additives, standards, deteriorative factors and their control, preliminary processing methods, conversion and preservation operations.	**05**
Food Preservation: Preservation by heat and cold, dehydration, concentration, frying, irradiation, micro wave heating, sterilization and pasteurization, fermentation and pickling and by various packing methods.	**06**
Production and Utilization of Food Products: Cereal grains, pulses, vegetables, spices, fats and oils, bakery, confectionery and chocolate products	**04**

Food Processing: Soft and alcoholic beverages, dairy products, meat, poultry and fish products, treatment and disposal of food processing wastes. **05**

Food Analysis: Moisture, ash, crude protein, fat, crude fiber, carbohydrates, calcium, potassium, sodium and phosphate. Food adulteration; common adulterants in food, contamination of food stuffs, microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample; HPLC, gas chromatography for organophosphates; thin-layer chromatography for identification of chlorinated pesticides in food products. **08**

Learning Outcomes:

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

- Develop an ability to design systems, components, and processes to meet desired needs applicable to process and store food products properly.
- Investigate the composition of the food through many analytical and inexpensive chemical methods.
- Develop modern techniques, skills, and tools necessary for the production of bakery, beverages, dairy products, and meat, poultry, and fish products and so on.
- Learn the current scenario of the World food industry and be able to compare the status of Bangladesh in this sector.

Reference Books:

- Heid J.L. & Joslyn M. A., Fundamentals of Food Processing Operations, AVI Pub
- Potter N.N., Food Science, AVI Pub
- Waston E.L., Elements of Food Engineering, Van Nostrand-Reinhold.
- Ronsivalli L.J., Elementary Food Science, Van Nostrand-Reinhold.
- Considine D.M., Considine G.D. &Considine P.E., Foods & Food Production Encyclopedia, Van Nostrand-Reinhold.
- Goldberg I., Biotechnology & Food Ingredients, Van Nostrand-Reinhold.

Semester – II

ACCE 5201: Textile Fibers and Dyeing Technology **Credit: 3.0**
3 Hours/Week

Description:

Textiles and apparel industries are a great scope for the graduates of Applied Chemistry and Chemical Engineering, and therefore, they should have basic knowledge of textiles. This course is designed to introduce students with the origin and classification of fibers, physical and chemical properties of natural and synthetic fibers, different spinning methods, basics of dyeing, different dyeing methods, finishing and testing of fibers and fabrics and their uses.

Objectives:

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

- Origin and classification of fibers.
- Physical and chemical properties of natural and synthetic fibers.
- Yarn manufacturing and numbering systems.
- Different spinning methods and their applications.
- Introduction to chemical dyes and basic chemistry behind them.
- Different dyeing methods, finishing and testing of fibers and fabrics and their uses.

Contents:	**No. of Classes**
Introduction: Classification of textile fibers according to their nature and origin, Essential and desirable properties of textile fibers, Staple fiber and continuous filaments, Comparison of natural and manmade fibers.	**02**
Natural Fibers: Vegetable based fibers (bast, leaf and seed fibers), Cotton: Concept of varieties, Definition of grading, Distinctive properties and end uses. Jute and Flax varieties, distinctive properties and end uses.	**03**
Animal Based Fibers: Wool; classification, distinctive properties and end uses; Silk: classification, distinctive properties and end uses.	**02**
Man-made Fibers: Classification; Synthetic fibers: Principles of polycondensation with reference to polyesters, polyamides and polyurethanes, principles of polyaddition with reference to acrylics, polyolefins, polyvinyl chlorides and co-polymers, chemical properties & end uses of polyester, polyamide and poly acrylonitrile fibers.	**04**

Yarn Manufacturing and Numbering Systems: Introduction to yarn manufacturing, principles of melt spinning, dry spinning and wet spinning, numbering systems; direct and Indirect system, British, Tex, Denier systems. **04**

Textile Dyes: Concepts and theories of colored substances, visible color, chromophores and auxochromes, qualities desirable for a dye, sources of dyes, nomenclature and classification of dyes, selection of dyes, and synthesis of some reactive and direct dyes. **04**

Chemistry and Operation of Dyes: Exhaustion and Fixation of dyes, Kinetics of dyeing, effect of dye concentration, electrolyte, temperature, pH, machine and agitation time on dye uptake, chemistry of reactive, direct, mordant and vat dyeing. Dyeing operations with preparation of fiber and fabrics (mercerization, scouring, desizing, washing etc), details of dyeing techniques, conditions and bath preparations. **05**

Finishing and Testing: Mechanical finishing of cotton, application of resins for finishing, properties imparted by finishing operation, single-bath dyeing and finishing, finishing of silk, wool and linen, special finishing operations. Methods of determining wash, light and rubbing fastness, Evaluation of fastness properties with the help of grey scale. **04**

Learning Outcomes:

After completion of this course student will be able to-

- Understand the essential and desirable properties of textile fibers and their classifications.
- Know the preparation, the physical and chemical properties of various natural fibers (e.g. cotton, bast fiber and leaf, silk, wool), regenerated fibers and synthetic fibers (e.g. polyolefin fibers, polyamides, acrylic, polyesters etc.) and some special fibers.
- Understand the technology and process of dyeing and finishing of textiles and their effects on fabrics.
- Identify ways in which textiles can influence our health, comfort and environment.

Reference Books:

- Kadolph, S. J. & Marcketti, S. B., (2017). Textiles (12th ed.). Upper Saddle River, New Jersey: Pearson Prentice Hall
- Textile Chemistry, Vol. I, by R.H. Peters.
- Manmade Fibres by R.W. Moncrieff.
- Handbook of Fiber Science and Technology, Vol. IV, Fiber Chemistry by M. Lewin and E.M. Peare.
- Man-made Fibres Science and Technology, Vol. 1,2,3 by H.F. Mark, S.M. Atlas and E. Cernia,
- Polyester Fibres Chemistry and Technology by H. Ludwig,

- Textbook of Polymer Science by F.W. Billmeyer.
- Chemical Technology of Fibrous Materials: F. Sadov, M. Korchagin, A. Matetsky, Translated by N. Chernyshova, Mir Publishers, Moscow, 1973.
- Series of Textile Technology: V. A. Sheni.

ACCE 5202: Nanoscience and Nanotechnology **Credit: 3.0**
3 Hours/Week

Description:

This course introduces Applied Chemistry and Chemical Engineering students (MS) to the field of nanoscience and nanotechnology. In this course students receive a set of formal lectures introducing them to the field of nanoscience and nanotechnology. The material covered includes nanomaterials synthesis, characterization techniques related to nanoscience and nanotechnology, application of nanomaterials, and handling, safety and hazard of nanomaterials processing.

Objectives:

- To introduce and provide a broad view of the emerging field of nanoscience and nanotechnology.
- To introduce students to understand the synthesis processes and characterization techniques of nanomaterials.
- To introduce the working principles of different instruments.
- To introduce the broad applications fields of nanomaterials and safety hazard of nanomaterials processing.

Contents: **No. of Classes**

Introduction to Nanotechnology: Importance of nanotechnology, history of nano technology, properties of nanomaterials, difference between bulk and nanomaterial, molecular building blocks for nanostructure systems. Influence of Nano structure on mechanical, optical, electronic, magnetic and chemical properties. Overview of different nanomaterials available, nanoscale, electromagnetic spectrum, particle size, chemistry and physics of nanomaterials, electronic phenomenon in nanostructures, optical absorption in solids, quantum effects. **04**

Nanomaterials Synthesis: "Top-Down" and "Bottom-Up" approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots) synthesis. Top-down techniques: photolithography, particle-beam lithographies (e-beam, FIB, shadow mask evaporation), probe lithographies. Bottom-up techniques: self-assembly, self-assembled monolayers, directed assembly, layer-by-layer assembly. Pattern replication techniques: soft lithography, nanoimprint lithography. Quantum dots, gold, silver, different types of nano- **07**

oxides, Al_2O_3, TiO_2, ZnO etc. Carbon nanotubes, preparation properties and applications like field emission displays.

Characterization Techniques Related to Nanoscience and Nanotechnology: Compositional surface analysis; XPS, SIMS, contact angles. Microscopies; optical microscopy, fluorescence, TEM, SEM, Probe techniques; scanning tunneling microscopy (STM), atomic force microscopy (AFM), Neutron Scattering and XRD. Spectroscopic Techniques; UV-visible, FT-IR, Raman, NMR, ESR. **07**

Application of Nanomaterials: Molecular motors, energy storage, electronic-nano particles for molecular diagnostics, nano biosensors, nanopharmaceuticals, nanoparticle-based drug delivery, nanostructures for tissue engineering/regenerative medicine etc. Ethical safety and regulatory issues of nanomedicine. **06**

Handling, Safety and Hazard of Nanomaterials Processing: Safety precautions at lab and manufacturing level; Temperature-Pressure and other physical effects. Effect of nanomaterial exposure on human and living stock, long term and short term effects-Case studies of Titania-Asbestos and Carbon-nanoparticle exposure. Effect of Nanoparticles on air, water and soil; food and food supplements and cosmetics **04**

Learning Outcomes:

Upon completion of the course, students will

- Have a working knowledge of nanoscience and nanotechnology, including theory and experiment.
- Be able to understand which synthesis process should be selected for a desired nanomaterial synthesis.
- Be able to understand which characterization and analysis instruments are necessary to apply for a specific nanomaterial prepared by themselves.
- Propose potential projects in nanoscience/nanotechnology.
- Potentially be able to join a research group in nanoscience/nanotechnology as a student researcher

Reference Books:

- Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
- Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
- Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
- Micro and Nanofabrication, Zheng Cui, Springer 2005
- Nanostructured materials, Jackie Y. Ying, Academic press 2001

- Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
- Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor& Francis 2006.
- Hand book of Nano science, Engineering, and Technology, William A. Goddard, CRC press 2003.
- Nanotechnology Environmental health and Safety: Risks Regulation and Management, Matthew Hull and Diana Bowman, Elsevier 2010.
- Nanomaterials: Risks and Benefits. Edited by Igor Linkov and Jeffery Steevens, Nato Science for Peace and Security Series-C,: Environmental Security, Springer 2009.

ACCE-5203: Biochemical Engineering **Credit: 3.0**
3 Hours/Week

Description:

This course will introduce basic aspects of biochemical engineering, cells and cell biochemistry, basics of genetic engineering, sterilization and its implication, enzymology, design aspects of bioreactors.

Objectives:

- The major objective of the course is to develop and enhance skills in the areas of biotechnology and biochemical processes focusing on the fundamental topics such as:
- Cells and Cell biochemistry including structural and functional aspects of important cell chemicals and genetic engineering.
- Basic theories and related topic of sterilization of media, fermenter, mass balance, and energy balance of biochemical processes.
- Enzymes and roles of enzymes, classification and structure of enzymes, kinetics of enzymatic processes, enzyme inhibition, production, immobilization and applications of enzymes, bioenergetics, AMP and TCA cycles.
- Designing bioreactors, different type of bioreactors, upstream and downstream operations involved in biochemical processes, product recovery etc.

Contents: **No. of Classes**

Introduction to Biochemical Engineering: Comparison of chemical and biochemical processes. Microbiology; general idea on structure of cells (prokaryotes and eukaryotes) and cell theory. Classification of microorganisms (protist kingdom) and their morphological characteristics e.g. Bacteria, blue; green algae, actinomycetes, fungi (mold, yeasts), protozoa (primitive animals) and algae (primitive plants). Biochemistry; study of structure, properties and functions of important cell chemicals like lipids (fatty acids, fats, **07**

vitamins, steroids, phospholipids) and carbohydrates, proteins and nucleic acids. Molecular genetics; concept and definition, process of gene expression; DNA replication and mutation, recombinant DNA technology, prospects of genetic engineering.

Sterilization: Principle of Sterilization, Method of Sterilization, Sterilization validation, Media for industrial fermentation, Sterilization of media and air. **04**

Aeration and Agitation: Stoichiometry of cell growth and product formation, oxygen requirement of industrial fermentation, Oxygen supply, resistance to oxygen transfer and role of diffusion, mixing in fermenters, role of shear in stirred fermenters, Energy through cAMP pathway and TCA, Importance of NAD and ATP, energy balance. **05**

Enzyme: Classification, comparison of enzymes with synthetic catalysts, kinetics of enzyme catalyzed reactions-Michealis-Menten equation for single substrate reaction; concept of substrate and substrate-enzyme complex. Evaluation of kinetic parameters in M-M equation. Substrate inhibition and activation. Feedback inhibition. Competitive and non-competitive inhibition. Enzyme activation and inhibition. Study of parameters affecting enzymatic activity like pH, temperature and mechanical forces. Production and purification of enzymes. Immobilization of enzymes (physical and chemical methods). Applications of enzymes as catalysts. Industrial, medical and analytical applications of immobilized enzymes. **05**

Design and Analysis of Biological Reactors: Ideal reactors and non-ideal reactors, sterilization of reactors, multiphase reactors; packed type, bubble column, fluidized bed, fixed bed (general description). Fermentation technology; design and operation of typical aseptic aerobic fermentation process. Different configurations for fermenters. Product recovery operations filtration, centrifugation, extraction, sorption, precipitation, chromatography and membrane processes. Bio-chemical industry; flow diagrams and descriptions for production of fine chemicals like enzymes, proteins, antibodies, steroids. **07**

Learning Outcomes:

Students will be able to:

- Understand the fundamentals of Biochemical processes such as cell biochemistry, roles of different cell constituents, cell replication, recombinant DNA technology etc.
- Comprehend the unit operations in biochemical processes such as sterilization and related topics, sterilization validation, media preparation.
- Explain enzymatic processes, kinetics, and inhibition of enzymatic processes, production and application.
- Explain design aspects of bioreactors with special references to mass balance, energy balance, stirring, supply of oxygen etc.

- Understand separation and purification of bio-products.
- Choose bioreactor and conduct bioprocess monitoring/control.

Reference Books:

- Bailey & Ollis, Biochemical Engineering Fundamentals, McGraw Hill
- M.L.Shuler and F.Kargi, Bioprocess Engineering, Prentice-Hall of India
- Pauline Doran, Bioprocess Engineering Principles, Elsevier
- Perry R.H. & Chilton H.C. (Eds.), Chemical Engineers Handbook, McGraw Hill
- 'Biochemical Engineering' by A.Aiba, E.Humphrey and N.R.Milli
- 'Bioprocess Engineering - Basic Concepts' by M.L.Shuler and F.Kargi
- 'Biochemical Engineering' by J.M.Lee
- 'Biochemical Engineering' by H.W.Blanch and D.S.Clark
- Bailey, J.E. and Ollis, D.F., "Biochemical Engineering Fundamentals", McGraw-Hill.

ACCE-5204: Environmental Pollution and Industrial Waste Management **Credit: 3.0** **3 Hours/Week**

Description:

Our life is very much dependent on environment for food, shelter, water supplies, etc. Adverse impacts to this environment affect our lives and other living organisms. Therefore, this course is designed to give the students an understanding of environmental systems, causes of environmental problems, and strategies to mitigate or manage these issues, sources of wastewater of different industries and their treatment processes.

Objectives:

Today, there is a great need to increase the productivity of chemical industries through implementation of pollution-free and environment-friendly technologies. This will be helpful in achieving economic, social, and environmental development objectives. In Bangladesh, the intense and uncontrolled process of economic change has led to an unprecedented impact on natural resources and environmental pollution. This course will demonstrate-

- An interdisciplinary approach to complex environmental problems;
- An awareness about several environmental problems from the experience of past events;
- A basic knowledge about the wastewater of various industries and their treatment processes;
- The ability to work effectively as a member of an interdisciplinary team of environmental issues.

Contents:	**No. of Classes**
Some Pollution Case Study: Londong Smog, Bhopal disaster, Fukushima and Chernobnyl disaster, etc. Air quality standards, sampling and monitoring.	**03**
Natural Water-Eutrophication: Removal of nitrogen, phosphorous bacteria and viruses from wastewater. Heavy metals and their removal. Sources and effects of pollution by mercury, lead, arsenic and chromium. Mitigation options, case studies-bioamplification, Minamata diseases.	**06**
Industrial Monitoring: Concept of threshold limit value, time weighted average and short term exposure limits. Methods of monitoring, exposure, active and passive sampling, grab sampling, diffusive monitors, analytical techniques.	**05**
Wastewater Treatment: Origin of wastewater; characterization of wastewaters; sampling and methods of analysis; methods and equipment used in wastewater treatment: preliminary treatment; primary treatment; Secondary (Biological) treatment, Sludge treatment and disposal; Advanced or tertiary treatment, Recovery of materials from process effluents.	**06**
Wastewater from some typical industries: Pulp and paper, tanneries, fertilizer, sugar industry, textile, soap and detergent manufacturing, chloro-alkali industry, thermal and nuclear power plants.	**04**
Current industrial environmental status; Guidelines and discharge standards of various industries permit system for discharge. Procedures for undertaking EIA and their evaluation.	**04**

Learning Outcomes:

After studying this course, students will be able to:

- Understand different terminologies related to environmental science and management
- Know the natural disasters, causes, impacts etc. happened in the past.
- Impart knowledge about monitoring and controlling of air pollution
- Impart knowledge about the characteristics of wastewater of different industries and their treatment procedures
- Gather knowledge about the EIA and its evaluation

Reference Books:

- Waste Water Engineering- Treatment Disposal and Reuse, Metcalf & Eddy, Tata McGraw Hill

- Air Pollution Control Engineering, Noel De Nevers, McGraw Hill
- Air Pollution: It's a origin and control, K. Wark, C. F. Werner and W. T. Davis, A Dun-Donnelley Publisher, New York
- Environmental Pollution Control, C. S. Rao, CBS Publishers
- Environmental Engineering, H. S. Peavy, D. R. Rowe, G. Tchobanoglous, McGraw Hill.
- Environmental Chemistry, A. K. De.
- Waste water treatment, M.N. Rao and A.K. Datta.
- Environmental Assessment in Practice, D. Owen Harrop and J. Ashley Nixon.
- Environmental Chemistry, John W. Moore & Elizabeth A. Moore

ACCE-5205: Industrial Training **Credit: 3.0**

Description:

Industrial in plant training refers to work experience done during the program of MS that is relevant to professional or practical development prior to the completion of the theoretical courses. In this course a student will visit at any industry after the end of the second semester based on the availability of the industry located in the suitable area of the country. For the student of MS generally the training session will continue for four weeks. In general, from a list of fertilizer industry, pulp and paper industry, pharmaceutical industry, natural gas fields, glass industry and cement industry. Student can choose any one of them for their training purpose.

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 applying 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 in oral and written approach.

This training session also gives an opportunity to assess future employees. A demonstrated commitment and ability to take responsibility, to 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

Viva-Voce **Credit: 2.0**

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. As well as, a student can be evaluated based on his/her efficiency in answering questions from the courses of previous year he/she has been passed so far.

Semester - III

In this semester a student can enroll either in non-thesis or in thesis group.

ACCE 5000: Thesis **Credit: 8.0**

A thesis student is to be involved with a supervisor to carry out a specific research work throughout this semester. At the end of this semester the final dissertation should be given by the student about his/her innovative research work in presence of examination committee members. S/he.is needed to submit a report on the research work carried out in this semester. Noted that, this research work is conducted by the student-supervisor interest in any specific field of science relevant to the academic background e.g., Material Science, Nanotechnology, Environmental engineering, Biomedical sciences etc.

ACCE 5000: Applied Chemistry and Chemical Engineering Lab **Credit: 8.0**

For the non-thesis students the practical experiments shall be designed by the committee of courses of the department and these experiments are divided into 04 (four) sections and each part will be conducted under the supervision of a group of teachers as assigned by the academic committee of the department.

Description:

This course is divided into four different parts based on their unique properties. The sections are-

Part I: Industrial Analysis

Part II: Chemical Engineering

Part III: Fuel & Petro-Chemical Engineering

Part IV: Pharmaceutical Quality Control

This course will offer the learners to develop a practical knowledge and skill of analyzing various material related to our daily life. e.g., Analysis of biomass, textile fibers, pulp and paper, water, polymers, petrochemical based fuels, coal, pharmaceutical products and so on. 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:

The major objective of this course is to introduce students in analyzing many industrially valuable products starting from motor fuel to pharmaceutical products. In case of investigating the

properties of these materials variegated chemical and analytical techniques was applied , which will developed the knowledge of analyzing the products under any circumstances.

Contents **No. of Classes**

Part I: Industrial Analysis **24**

- Analysis of biomass- Analysis of alpha; beta & gamma celluloses in a cellulose sample
- Analysis of textile fibers - Cotton; wool; silk etc.
- Testing of pulp and paper
- Testing of plastics and rubber.
- Analysis of water.
- Determination of the purity of the supplied sample of urea.
- Identification of functional groups in polymers.
- Determination of the percentage of formaldehyde in the supplied formalin solution

Part II: Chemical Engineering **24**

- To determine the effect of viscosity index improver (polymethacrylate) on the viscosity index of Motor oil.
- To determine the boiling range of kerosene and calculate the amount recovered and distillation loss for the given sample of kerosene. Also determine the percentage of purity of the product.
- Extractive distillation for separation of aromatics from non-aromatics.
- Determination of Octane number of gasoline
- Determination of Cetane number of diesel fuel.
- Determination of functional group of mineral and synthetic oil with the help of IR.
- To determine the flash point of the given liquid fuel.
- To determine aniline point of an oil.
- To determine the diesel index of the given oil sample.
- Separation of petroleum products by chromatography.
- Solvent extraction of aromatics from a given mixture of aromatics and paraffins.
- TBP distillation of BTX mixture.
- Catalytic hydrodesulphurization.
- Catalytic cracking of petroleum products

Part III: Fuel & Petro-Chemical Engineering **24**

- Calorific values of gaseous fuels.
- To determine the calorific value of a gaseous fuel from the rise of temperature and volume of water heated.
- Proximate analysis of coal.
- To determine the proximate analysis of the given coal sample.

- Calorific value of solid fuel.
- To determine the calorific value of coal by Bomb calorimeter.
- Conradson carbon residue test.
- To determine the carbon residue for the sample of the given oil.
- Chlorination of alkylaromatic compounds.
- Separation of petroleum products by chromatography.
- Synthesis of detergent of the alkylsulphate type.

Part IV: Pharmaceutical Quality Control **24**

- Qualitative and quantitative analyses of pharmaceutical raw materials and finished drugs will be carried out involving: Appearances, solubility, identification, pH of aqueous solution.
- Potency determination by titrimetric, spectrophotometric and HPLC method of both active ingredients e.g., Paracetamol, Amoxycillin, Loratidine, Ciprofloxacin, Diclofenac sodium etc. and excepients e.g., Maize starch, Lactose, Povidone, Microcrystalline cellulose, Sorbitol etc.

Learning Outcomes:

At the end of part-I, students will be able to -

- Differentiate among the textile fibers.
- Determination of the purity of the supplied sample of urea.
- Analyze bio-mass, plastics, polymers, rubbers, water etc.
- Determination of the percentage of formaldehyde in the supplied formalin solution.

At the end of part-II, students will be able to -

- Determine the effect of viscosity index improver (polymethacrylate) on the viscosity index of motor oil.
- Find out the flash point, amine point, and pour point of supplied given liquid fuels.
- Determine the boiling range of kerosene and calculate the amount recovered and distillation loss for the given sample of kerosene. Also determine the percentage of purity of the product.
- Measure octane number, cetane number of gasoline and diesel fuel respectively.
- Separate the petroleum products by Chromatography.
- Learn the process of catalytic cracking of petroleum products and so on.

After the successful completion of part-III students will be able to-

- Find out the calorific value of solid and gaseous fuels
- Determine the chlorination characteristics of alkylaromatic compounds.
- Separate the petroleum products by chromatography.

- Synthesis of detergent of the alkylsulphate type etc.

At the end of part-IV, students will be able to -

- Qualitative and quantitative analyses of pharmaceutical raw materials and finished drugs.
- Investigate the appearance, solubility, pH of aqueous solution etc. of drug and the excipients.
- Determine the potency by titrimetric, spectrophotometric and HPLC method of both active ingredients and excipients.

THE END