COMSATS University Islamabad

Registrar Secretariat, Academic Unit (PS)

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No. CUI-Reg/Notif- 1185 /26/EFS: 64381 August 31, 2026

NOTIFICATION

The Academic Council, in its 44th meeting held on August 04, 2026, on the recommendations of the Board of Advanced Studies and Research (BASAR) in its 39th meeting held on June 30, 2026, approved the revised Scheme of Studies of **Master of Science in Energy and Environmental Engineering**, effective from Fall 2026.

1. Duration of the Program:

i.	Minimum Duration with **Thesis option**	02 Years
ii.	Minimum No. of Semesters with **Thesis option**	04 Semesters
iii.	Minimum Duration with **Non-Thesis option**	1.5 Years
iv.	Minimum No. of Semesters with **Non-Thesis option**	03 Semesters
v.	Maximum Duration for both **Thesis/ Non-Thesis options**	04 Years (08 semesters)

2. No. of Courses and Credit Hours in MS With (Thesis/ Non-Thesis option):

S. No.	Category	SAME/RELEVANT* DISCIPLINE		INTRA-DISCIPLINARY	
		No. of Courses	No. of Credit Hours	No. of Courses	No. of Credit Hours
vi.	**Deficiency Courses of level 6**	-	-	02-03	06-09
vii.	**Core Courses**	04	12	04	12
viii.	**Mandatory Course**	03	05	03	05
ix.	**Elective Courses**	03	09	03	09
x.	**Research Thesis**	01	06	01	06
xi.	**Total**	**11**	**32**	**13-14**	**38-41**

† Non-Muslim students shall study HUM751 Essentials of Ethics as alternative to the two core courses: Essentials of Understanding of Holy Quran I & II. For these students, the number of Mandatory courses is 02 resulting in total 10 courses for same/ relevant discipline and total 12-13 courses for intradisciplinary category.

3. **For Non-Thesis Option:** The students are required to complete a minimum of two courses totaling 6 credit hours as coursework in lieu of a research thesis to fulfill the requirements for the MS degree in addition to the compulsory non-credit MS Project/Report.
4. *Where necessary, relevancy will be determined by the concerned Dean, pursuant to the provisions of the Graduate Handbook as amended from time to time.

For INTRADISCIPLINARY:

5. For prospective graduate students coming from an Intra-disciplinary field must take two tests, i.e., the GRE Subject and GRE/NTS/HAT General / Equivalent as per CUI rules and

regulations/Graduate Handbook.

6. Subject to fulfilment of other prescribed requirements, the department may award provisional admission and allow the prospective student to take deficiency courses as per CUI rules and regulations/Graduate Handbook. Admission may be confirmed after successful completion of deficiency courses. The zero semester of an intradisciplinary MS candidate shall not count towards the maximum study duration.
7. The credit hours earned through deficiency courses shall be mentioned in the student's transcript, however, shall not be counted towards calculating CGPA of the degree.

General:

8. MS students may enroll only in courses numbered 600-799, except for the MS Thesis (800).
9. **Deficiency Courses:** The requirement for deficiency courses shall be determined as per policy/ CUI Graduate Handbook, as amended from time to time.
10. **General Eligibility Criteria:** The general eligibility criteria for admission into MS Program remain as prescribed in the CUI Graduate Handbook.

    To assess the relevance of applicants' academic background for admission into the same/relevant disciplines category, the Departmental Admission Committee shall:

    - Review the applicant's academic credentials, including transcripts and degree(s).
    - Conduct an interview to evaluate suitability for the respective program.

    Based on this evaluation, the Departmental Admission Committee shall forward its recommendations to the Dean's Office through the proper channel for endorsement of the final decision.
11. All other requirements, terms, and conditions stipulated in the CUI Graduate Rules/ Regulations/ Policy and Graduate Handbook, as amended from time to time, shall also be applicable.
12. The respective Campus Director must ensure that the program secures the necessary accreditation and/or NOC from the relevant Accreditation Council(s) or HEC, where applicable. Maintaining continuous accreditation is essential to safeguard student credentials and prevent future qualification or recognition issues for graduates.

This partially modifies notification number CUI-Reg/Notif-807/26/EFS 23678 dated May 11, 2026.

Dr. Muhammad Hanif
Additional Registrar

Encl: (Total 130 Pages)

Distribution:

1. All Campus Directors / In-Charge, CUI Campuses
2. All Principal Officers / All Deans of Faculties
3. All Chairpersons of Academic Departments / All Heads of Departments
4. Treasurer / Controller of Examinations / In-Charge: Planning & Development / HRD
5. All In-Charge (Academics / Examination / Registration / Admission / Accounts / HR), CUI Campuses
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8. Registrar Office / Academic Unit, CUI Principal Seat

CC:

1. SO to the Rector
2. PS to the Registrar

1. **Core Courses:**

S. No.	Code	Course Title	Credit Hours
1.	ENE611	Nanotechnology and Energy	3(3, 0)
2.	ENE613	Renewable Energy Technologies	3(3, 0)
3.	ENE621	Air Pollution Control	3(3, 0)
4.	ENE622	Water and Wastewater Treatment	3(3, 0)

2. **Mandatory Courses:**

S. No.	Code	Course Title	Credit Hours
1.	HUM701	Essentials of Understanding of Holy Quran-I	1(0, 1)
2.	HUM702	Essentials of Understanding of Holy Quran-II	1(0, 1)
3.	CSC705	Artificial Intelligence in Practice	3(3, 0)

3. **Mandatory Alternative Course for Non-Muslim Students in Lieu of Quran Courses*:**

S. No.	Code	Course Title	Credit Hours
1.	HUM751	Essentials of Ethics	2(0, 2)

*Shall be effective from Fall 2025 intakes

LIST OF ELECTIVE COURSES:

a) MS students, with thesis options, are allowed to enroll in any three (03) courses numbered 600-799 from the following list.

b) MS students, with non-thesis options, are allowed to enroll in any five (05) courses numbered 600-799 from the following list.

Sr. No.	Course Code	Course Title	Credit Hours
1.	CHE601	Instrumental Analytical Techniques	3(3, 0)
2.	CHE602	Advanced Chemical Kinetics & Reaction Engineering	3(3, 0)
3.	CHE603	Advanced Chemical Engineering Thermodynamics	3(3, 0)
4.	CHE604	Advanced Transport Phenomena	3(3, 0)
5.	CHE605	Advanced Numerical and Statistical Analysis	3(3, 0)
6.	CHE606	Engineering Research Methods	3(3, 0)
7.	CHE610	Petroleum Fluids	3(3, 0)
8.	CHE611	Combustion Engineering	3(3, 0)
9.	CHE620	Life Cycle Analysis	3(3, 0)
10.	CHE621	Industrial Environmental Biotechnology	3(3, 0)
11.	CHE630	Advanced Biochemical Engineering	3(3, 0)

12.	CHE631	Bio-Chemical and Food Technology	3(3, 0)
13.	CHE632	Biotechnology and Environmental Processes	3(3, 0)
14.	CHE640	Industrial Polymer Chemistry	3(3, 0)
15.	CHE641	Rubber and Plastics Materials	3(3, 0)
16.	CHE642	Composite Materials	3(3, 0)
17.	CHE643	Polymer Physics	3(3, 0)
18.	CHE644	Colloid and Surfactant Science	3(3, 0)
19.	CHE645	Polymer Testing	3(3, 0)
20.	CHE646	Plastic Technology	3(3, 0)
21.	CHE650	Technology of Textile Wet Processing	3(3, 0)
22.	CHE651	Technical Textiles	3(3, 0)
23.	CHE652	Pre-Chemical Treatment Processes of Textile	3(3, 0)
24.	CHE653	Processes for Cotton Dyeing	3(3, 0)
25.	CHE654	Textile Printing	3(3, 0)
26.	CHE678	Plasma Chemical Engineering	3(3, 0)
27.	CHE690	Emerging Topics in Chemical Engineering	3(3, 0)
28.	CHE695	Integrative Approaches to Chemical Engineering Research	3(3, 0)
29.	CHE696	Dimensionless Groups: Advanced Applications and Techniques in Chemical Engineering	3(3, 0)
30.	CHE697	Advanced Reaction Engineering	3(3, 0)
31.	CHE698	Advanced Heat and Mass Transfer Operations	3(3, 0)
32.	CHE700	Advanced Treatment of Simultaneous Heat and Mass Transfer	3(3, 0)
33.	CHE701	Computational Fluid Dynamics	3(3, 0)
34.	CHE702	Advanced Catalytic Processes	3(3, 0)
35.	CHE703	Fluidization Engineering	3(3, 0)
36.	CHE704	Novel Separations	3(3, 0)
37.	CHE710	Oil and Gas Economics	3(3, 0)
38.	CHE711	Surface Petroleum Operations	3(3, 0)
39.	CHE712	Petroleum Transmission	3(3, 0)
40.	CHE713	Natural Gas Transmission	3(3, 0)
41.	CHE720	Chemicals Emission and Control	3(3, 0)
42.	CHE721	Fate and Transport of Chemical in Environment	3(3, 0)
43.	CHE722	Industrial Environmental Microbiology	3(3, 0)
44.	CHE723	Industrial Environmental Chemistry	3(3, 0)
45.	CHE724	Hazardous and Toxic Chemical Waste Treatment	3(3, 0)
46.	CHE725	Bioremediation of Toxic Chemicals	3(3, 0)
47.	CHE726	Solid Waste Engineering	3(3, 0)
48.	CHE730	Bio-Reaction Engineering	3(3, 0)
49.	CHE731	Bio-Process Design	3(3, 0)
50.	CHE732	Production of Biofuels	3(3, 0)
51.	CHE733	Metabolic and Cell Engineering	3(3, 0)

52.	CHE734	Manufacturing Practices for Bioprocesses	3(3, 0)
53.	CHE740	Polymer Rheology	3(3, 0)
54.	CHE741	Principles of Polymer Conversion Operations	3(3, 0)
55.	CHE742	Polymer Membranes	3(3, 0)
56.	CHE743	Sol-Gel Processing	3(3, 0)
57.	CHE744	Membrane Science & Technology	3(3, 0)
58.	CHE750	Textile Quality Assurance	3(3, 0)
59.	CHE751	Mechanics of Textiles	3(3, 0)
60.	CHE752	Advanced Yarn Engineering	3(3, 0)
61.	CHE753	Fiber Forming Polymers	3(3, 0)
62.	CHE754	Fiber Engineering Science	3(3, 0)
63.	CHE760	Scientific Communication for Engineering Research	3(3, 0)
64.	CSC762	Advanced Topics in Neural Networks	3(3, 0)
65.	ENE612	Clean Coal Technologies	3(3, 0)
66.	ENE623	Solid Waste Management	3(3, 0)
67.	ENE624	Environmental Pollution Control	3(3, 0)
68.	ENE714	Advanced Energy Engineering	3(3, 0)
69.	ENE715	Waste to Energy	3(3, 0)
70.	ENE731	Energy and Environmental Policies	3(3, 0)
71.	ENE732	Special Topics in Energy and Environment	3(3, 0)
72.	ENV605	Environmental Impact assessment	3(3, 0)
73.	ENV606	Environmental Policies, Planning and Laws	3(3, 0)
74.	ENV622	Waste Water Treatment	3(3, 0)
75.	ENV751	International Environmental Governance	3(3, 0)
76.	ENV753	Climate Change and Global Politics	3(3, 0)
77.	MME611	Nano-materials	3(3, 0)
78.	MME612	Fracture, Creep, and Fatigue of Materials	3(3, 0)
79.	MME613	Metals and Alloys	3(3, 0)
80.	MME614	Thin Film Processing and Characterization	3(3, 0)
81.	MME615	Advanced Ceramics and Composites	3(3, 0)
82.	MME616	Advanced Materials Science	3(3, 0)
83.	MME617	Superalloys and High Performance Materials	3(3, 0)
84.	MME618	Product Design and Development	3(3, 0)
85.	MME619	Materials for Sensors and Electronics	3(3, 0)
86.	MME621	Materials for Solar Energy	3(3, 0)
87.	MME622	Materials for Energy and Environment	3(3, 0)
88.	MME631	Biological Materials	3(3, 0)
89.	MME641	Surface Engineering	3(3, 0)
90.	MME651	Corrosion Engineering	3(3, 0)
91.	MME661	Special Topics in Materials Engineering	3(3, 0)
92.	PSE601	Advanced Process Systems Engineering	3(3, 0)

93.	PSE610	Advanced Process Control	3(3, 0)
94.	PSE651	Advanced Process Economics	3(3, 0)
95.	PSE702	Process Integration	3(3, 0)
96.	PSE720	Process Design and Optimization	3(3, 0)
97.	PSE731	Process Modeling and Simulation	3(3, 0)
98.	PSE732	Artificial Neural Network	3(3, 0)
99.	PSE740	Sustainable Energy Systems	3(3, 0)
100.	PSE741	PINCH Technology	3(3, 0)
101.	PSE742	Energy Audit and Management	3(3, 0)
102.	PST611	Fundamental of Polymer Science and Technology	3(3, 0)
103.	PST621	Polymer Processing Technologies	3(3, 0)
104.	PST622	Elastomers Technology	3(3, 0)
105.	PST623	Polymer Blends and Composites	3(3, 0)
106.	PST629	Polymer Textile Fibers	3(3, 0)
107.	PST631	Polymer Chemistry	3(3, 0)
108.	PST641	Engineering Behavior of Polymers	3(3, 0)
109.	PST651	Characterization and Testing of Polymeric Materials	3(3, 0)
110.	PST653	Polymeric Coatings	3(3, 0)
111.	PST655	Special Topics in Polymer Science and Technology	3(3, 0)
112.	PST661	Polymeric Biomaterials	3(3, 0)
113.	PST671	Environment Impacts of Plastics and Recycling Technologies	3(3, 0)
114.	PST724	Polymer Process Machinery Technology	3(3, 0)
115.	PST725	Advanced Polymer Processing	3(3, 0)
116.	PST726	Plastic Products Manufacturing	3(3, 0)
117.	PST732	Advanced Polymer Synthesis and Processes	3(3, 0)
118.	PST733	Polymer Reaction Technology	3(3, 0)
119.	PST752	Advanced Polymer Characterization	3(3, 0)
120.	PST754	Polymers Surfaces and Interfaces	3(3, 0)
121.	PST762	Emulsion Polymers	3(3, 0)

MS Thesis/ Report:

S. No.	Course Code	Course Title	Credit Hours
1.	ENE600	MS Project/Report	0(0, 0)
2.	ENE800	MS Thesis	6(0, 6)

Course Title: Nanotechnology and Energy

Course Code: ENE611

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge of Nanotechnology and how it can help in making process more energy efficient.

Course Contents:

Introduction to Nano-Technology, Characteristics of Nano material, Nano particles, Bucky balls, CNTs and quantum dots, super capacitors, lithium ions battery, Hydrogen storage, Nano catalyst for optimized fuel production, Dye sensitized solar cell, quantum dot solar cell, semiconducting Nano-materials and photo catalyst, metal oxides and sulfides for hydrogen production, limitation of existing photo catalysts, Introduction to conducting polymers, organic light emitting diodes, conducting polymers solar cells.

Reference Books:

1. He, J. Nanomaterials in Energy and Environmental Applications. Pan Stanford, (2016).
2. Shah, M. A., Bhat M. A. and Davim, P. Functional Nanomaterials for Energy and Environmental Applications. Trans Tech Pubn, (2013).
3. Garcia-Martinez, J. Nanotechnology for energy challenge. (2nd ed.) Wiley-VCH, (2013).
4. Somorjai, G.A., H. Frei, and J.Y. Park. (2009). Advancing the frontiers in nanocatalyst, biointerfaces and renewable energy conversion by innovations of surface techniques, (1st ed.) (2009).
5. Wilson, M., K. kannangara, B.Raguse, and M. Simmon. Nano technology: basic Science and emerging technologies. (1st ed.) Chapman and Hall/CRC, (2002).

Course Title: Renewable Energy Technologies

Course Code: ENE613

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course discusses different aspects of renewable energies. It aims to present the fundamentals of renewable technologies and potential of renewable energy resources in Pakistan.

Course Contents:

Introduction; brief history of energy consumption, energy & environment and non-renewable energies. Renewable energies and potential resources in Pakistan. Solar energy; solar thermal energy and solar photovoltaics. Wind energy; wind turbines and environmental impact. Geothermal energy; geothermal technologies. Biomass to energy; kinetics and microbiology of biological processes and thermochemical conversion processes. Nuclear energy; radioactivity & radioactive charge, types of reactors, types of processes and general problem of reactor operation. Hydel energy; current generation power reactors (pressurized water reactors, boiling water reactors, gas-cooled reactors), hydro-electric power plants, hydrographs and flow duration curve. Case studies/ mini project/ feasibility reports.

Reference Books:

1. Sumathi, S., Kumar, L. A. and Surekha, P. Solar PV and Wind Energy Conversion Systems. Springer International Publishing, (2015).
2. Boyle, G. Renewable Energy: Power for a Sustainable Future. (3rd ed.) OUP Oxford, (2012).
3. Kishore, V.V.N. Renewable Energy Engineering and Technology: Principles and practice. The Energy and Resources Institute (TERI), (2009).
4. Kalogirou, S.A. Solar Energy Engineering: Processes and Systems. (1st ed.) British Library, (2009).
5. Viswanathan, B. and Scibioh, M.A. Fuel Cells: Principles and Applications. Taylor & Francis Group, (2007).
6. Boyle, G., Everett, B. and Ramage, J. Energy Systems and Sustainability. (2nd ed.) OUP and Open University, (2004).

Course Title: Air Pollution Control

Course Code: ENE621

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide the understanding of sources of air pollution and their effects on the environment. This course also covers different air pollution control strategies and the skills for selection and design of air cleaning equipment.

Course Contents:

Introduction; definitions, history and ambient air quality (EPA, NEQS). Air pollutants, their sources and harmful effects on the environment. Measurement and monitoring of air pollution; ambient air sampling, analysis and measurement of gaseous pollutants, particulate pollutants, odors, visibility and acidic deposition. The meteorology of air pollution; ventilation, stagnation, meteorological conditions during historic pollution episodes, transportation and dispersion of air pollutants. Methods for monitoring and control; selection of air pollution control equipment, control of stationary and mobile sources. Engineering control concepts; process change, fuel change, pollutant removal and disposal of pollutants. Removal of dry particulate matter and liquid droplets. Gas cleaning equipment and their design; cyclones, hydrocyclones, fabric filters, particulate scrubbers and ESPs. Emerging technologies in air pollution control.

Reference Books:

1. Harrison, R.M. Pollution: Causes, Effects and Control. (4th ed.) Royal Society of Chemistry, (2014).
2. Boubel, R.W., Vallero, D., Fox, D.L., Turner, B., and Stern, A.C. Fundamentals of air pollution. Elsevier, (2013).
3. Nevers N.D. Air Pollution Control Engineering. McGraw Hill Int, (2000).
4. De, A.K. Environmental Chemistry. Wiley Eastern Ltd, (1990).
5. Stern A.C. Air Pollution, Vol. 1-VIII, Academic Press, (1980).
6. Perkins H.C. Air Pollution. McGraw Hill, (1974).

Course Title: Water and Wastewater Treatment

Course Code: ENE622

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to provide the understanding of design and operation of unit processes and operations in industrial wastewater treatment.

Course Contents:

Drinking water quality and standards; introduction to water supply, WHO guidelines for drinking water, water-borne diseases. Introduction to water treatment processes; objectives and classification. Water treatment processes; coagulation and flocculation processes, slow sand filtration, rapid gravity filtration, air scouring, sludge treatment and handling, hardness removal, activated carbon filtration, ion exchange, membrane processes. Industrial and municipal waste. Introduction to wastewater treatment; classification of wastewater treatment stages and their layout. Primary treatment units; design of screening units, grit removal, design of sedimentation tanks. Secondary treatment; Fixed film reactors; introduction and theory of fixed film reactors, design and operation of trickling filters, rotating biological contactors, reactor tanks, mixed tanks. Tertiary treatment, Disinfection, odor removal.

Reference Books:

1. Cornwell, D.A. and Davis, M.L. Introduction to environmental engineering. Boston: McGraw-Hill, (2014).
2. Amjad, Z. (Ed.). The science and technology of industrial water treatment. CRC Press, (2010).
3. Stensel, H.D., Burton, F.L., Tchobanoglous, G., and Metcalf & Eddy. Wastewater engineering: treatment and reuse. Boston: McGraw-Hill, (2003).
4. Cheremisinoff, N.P. Handbook of water and wastewater treatment technologies. Butterworth-Heinemann, (2001).
5. Kawamura, S. Integrated design and operation of water treatment facilities. John Wiley & Sons, (2000).

Course Title: Instrumental Analytical Techniques

Course Code: CHE601

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Purpose of this course is to develop knowledge, and have hands-on experience and problem solving skills with various instrumental methods used for the data analysis and quantification in chemical engineering and allied fields.

Course Contents:

Spectroscopic techniques: Ultraviolet and Visible Spectroscopy (atomic absorption and UV-Visible), Infrared Spectroscopy (IR), Nuclear Magnetic Resonance Spectrometry (NMR), Vibrational Spectrometry (FT-IR, Raman), and X-ray spectroscopy (XRD). Separation techniques: Gas Chromatography (GC-TCD, GC-FID, GC-MS), Liquid Chromatography: High performance liquid chromatography (HPLC), and Thin Layer Chromatography (TLC). Microscopic techniques: Scanning Electron Microscope (SEM) and Transmission electron microscopy (TEM). Other techniques: Brunauer–Emmett–Teller (BET) and Differential Scanning Calorimetry (DSC), Thermogravimetric analysis (TGA)

Reference Books:

1. Dudley H. Williams, Ian Fleming, Spectroscopic Methods in Organic Chemistry, (7th ed.) Springer International Publishing, (2019).
2. Camp W., Organic Spectroscopy, (3rd ed.) PALGRAVE, (2002).
3. Harris, D.C., Quantitative Chemical Analysis, ((7th ed.)), W.H.Freeman, and company, New York (2006).
4. Palvia D. L., Lampman G. M., Kriz G. S. and Vyvyan J. R., Introduction to Spectroscopy, ((4th ed.)), Brooks/Cole, Belmont USA, (2009).
5. B.D. Culity and S.R. Stock, Elements of X-ray Diffraction, (3rd ed.), Prentice Hall, (2003).

Course Title: Advanced Chemical Kinetics & Reaction Engineering

Course Code: CHE602

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop an understanding of kinetics and apply it to postulate mechanisms of reactions. Describe and develop mathematical models in a catalytic reaction. To apply the mechanisms of reaction and mathematical models developed above to design different kind of chemical reactors. To develop a thorough understanding of chemical reaction engineering. After completing this course student will be able to design real world chemical reactors used in different process industries.

Course Contents:

Chemical kinetics, kinetics and thermodynamics, thermodynamics of chemical reactions. Kinetics of homogeneous reactions: rate of reaction, concepts of kinetics, Arrhenius law, Rate theories, activated complex theory, unimolecular reactions, and analysis of simple and complex rate equations. Kinetics of fluid-solid catalytic reactions. Batch and ideal flow reactors, semibatch reactors. Laminar flow reactors. Axial and radial dispersion in tubular reactors. Axial and radial temperature variations in tubular reactors. Design principles of gas-solid catalytic reactors. Consideration of noncatalytic/catalytic reactions in single fluid phases and emphasis on reactions in multiphase mixtures, especially gas-solid reactors. Reactor stability. Residence time distribution and segregation in flow reactors. Models for non-idealized reactors.

Reference Books:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, (4th ed.), Prentice Hall, New Dehli, India.
2. O. Levenspiel, Chemical Reaction Engineering, (1999), (3rd ed.), John Wiley, New York.
3. J. Smith, Chemical Engineering Kinetics, (1981), (3rd ed.), McGraw-Hill, New York.

Course Title: Advanced Chemical Engineering Thermodynamics

Course Code: CHE603

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To enhance student's fundamental knowledge of Chemical and Applied Thermodynamics of students and mastery of solving related complex engineering problems. To develop in depth knowledge of thermodynamics as quantitative subject and its application in typical chemical processes.

Course Contents:

Review of chemical engineering thermodynamics and applied thermodynamics. Phase Equilibria: VLE: Qualitative behavior, VLE by modified Raoult's Law, VLE from K-Value Correlations, LLE, SLE, SVE. Chemical Equilibria: Review of chemical Equilibria; Relation between Standard Gibbs-Energy Change and Equilibrium constant, relation of equilibrium constant and composition, Multi-reaction equilibria. Molecular Thermodynamics: Molecular Theory of Fluids, Second Viral Coefficients from Potential Functions. Thermodynamic Properties and statistical mechanics. Behavior of excess properties. Molecular basis for mixture behavior. Supercritical and subcritical Fluids; Formation, thermodynamics and their applications. Power Cycles: Review of advanced thermodynamic power cycles; Combined Heat and Power cycles (CHPs), IGCC, Chemical recuperation cycles. Refrigeration: Refrigerants, review of refrigeration cycles, Vapor Absorption cycle, steam-jet refrigeration, Liquefaction process; LNG. Case study: Computational heat transfer: Finite element formulation and analysis of 1-D Transient heat conduction, 2-D and 3-D steady state heat transfer using Fluent/Ansys/COMSOL Multiphysics.

Reference Books:

1. YVC Rao, Chemical Engineering Thermodynamics (2008). Universities Press India.
2. J.B. Jones, R.E. Dugan, Engineering Thermodynamics (1st ed.) (1995). Prentice Hall.
3. Michael J. Moran, Fundamentals of Engineering Thermodynamics (2nd ed.) (1992). John Wiley & Sons Inc.
4. Sandler, S. I., Chemical and Engineering Thermodynamics, (1998). Wiley.
5. Koretsky, M.D., Engineering and Chemical Thermodynamics, ((2nd ed.)). (2012). John Wiley & Sons, Incorporated.

Course Title: Engineering Research Methods

Course Code: CHE606

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of the course is to translate current research methods, which are mostly from a social science perspective, into something more relatable and understandable to engineers.

Course Contents:

What constitutes research? Philosophy and Epistemology. Research Ethics and Integrity, Critical appraisal. Types of Research. Research Design: Steps in the Process of Research, Identifying a hypothesis and/or research problem, Specifying a purpose, Creating research questions, Reviewing literature, Ethics of research and informed consent, confidentiality, intellectual property and potential patent issues. Literature search, review and citation practices. Problem identification, formulating research questions. Choosing a Methodology. Evaluating problems. Risk assessments for Engineers. OH&S legislation and codes of practice available to support research planning in science and engineering (including chemical management, manual handling, and electrical safety). Overview of Methodologies and Methods. Quantitative and qualitative methods - strengths and weaknesses. Introduction to Mixed Methods Research, Study Designs, and Methods, Common shortcomings in experimental design. Problems and Principles of Sampling. Types of Sampling. Sampling Concepts, Design Effect, Sampling Methods (Cluster, Stratified, Simple Random). Instrumentation and data logging. Data analysis, interpretation, and limitations. Validity, reliability, Error Analysis. Central Tendency and Dispersion, Associations, Data Mining, Correlation and data fitting. Applied, Descriptive and Inferential Statistics. Tests of Significance. Lab view®, Design Expert®, Response Surface Methodology. Data Presentation, Referencing & Software. Academic writing skills: critical concepts for the higher-level report and thesis writing. Critically Critiquing Research Reports. Research proposal writing. Communication with supervisors), networking with other research students and research organizations.

Reference Books:

1. Creswell, J. W. Research design: Qualitative, quantitative and mixed methods approach. (4th ed.) Thousand Oaks, CA: Sage, (2014).
2. McCormac, C. Davis, J. Papakonstantinou, P., & Ward, N. Research Project Success: The Essential Guide for Science and Engineering Students. Royal Society of Chemistry Publishing, Cambridge, UK, (2012).
3. Ranjit Kumar, (2011), Research Methodology: A step by step guide, Sage South Asia Publications Lawrence Neuman, (2010) ((7th ed.)), Research Methods, Pearson.

Course Title: Advanced Transport Phenomena

Course Code: CHE604

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To describe, predict, and manage changes such as velocity, temperature and composition in chemical engineering processes either to find solutions of these processes or to curtail lab experiments.

Course Contents:

Advanced treatment of momentum, energy & mass transport equations to describe laminar and turbulent systems of chemical engineering importance; specification of initial and boundary conditions; solutions of modeled set of equations; appreciation of computer generated results.

Reference Books:

1. Louis Theodre, Transport Phenomena for Engineers, (1990), International Textbook Company, London.
2. R.B. Bird, W.E. Stewart, E.N. Lightfoot, Transport Phenomena, (2002), (2nd ed.), John Wiley & Sons, Inc.
3. Hermann Schlichting, Boundary-Layer Theory, (1968), McGraw-Hill Book Company, New York.
4. D.E. Rosner, Transport Processes in Chemically Reacting Flow Systems, (1967), Butterworths, Boston.
5. R.S. Brodkey, The Phenomena of Fluid Motions, (1986), Addison-Wesley Publishing Co., London.
6. J. Szekely, N.J. Themelis, Rate Phenomena in Process Metallurgy, (1971), Wiley-Interscience, New York.

Course Title: Advanced Numerical and Statistical Analysis

Course Code: CHE605

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop strong understanding in methodic mathematical analysis reinforced with applied statistics for philosophical interpretations.

Course Contents:

Classification of Ordinary and Partial Differential Equations, Analytical Solutions of Ordinary and Partial Differential Equation; Integrating Factor; Method of Characteristics; Separation of Variables; Similarity Transformation; Laplace Transformation. Numerical Solutions of Ordinary and Partial DifferentialEquations; Initial and Boundary Value problems; Solution of non-linear and Stiff Ordinary Differential Equations; Solution of Partial Differential Equations Using Finite Difference and Finite Element Methods, Numerical Integration, Matrix Algebra, Linear and Non- Linear Algebraic Equations; Eigenvalues and Eigenvectors; Computer Programming of Numerical Methods. Introduction; Simple Comparative Experiments; Concept of Sampling and Sampling Distribution. Analysis of Variance; Experiments with Single Factor; Regression Approach to ANOVA; Randomized Blocks; Latin Square and Related Designs. Factorial Designs; 2k Factorial Designs with Blocking and Confounding; Two Level Fractional Factorial Designs; Three Level and Mixed Level Factorial and Fractional Factorial Designs. Fitting Regression Models; Optimization of Regression Models; Experiments with Random Factors; Nested and Split Plot Designs.

Reference Books:

1. Joseph Schmuller, Statistical Analysis with Excel for Dummies, (2009), CRC Press.
2. Richard A. Johnson, Applied Multivariate Statistical Analysis, (2007), (6th ed.), Prentice Hall.
3. Nicholas J. Horton, Using R for Data Management, Statistical Analysis, and Graphics, (2010), John Wiley & Sons Inc.
4. David MacKinnon, Introduction to Statistical Mediation Analysis (Multivariate Applications Series), (2008), John Wiley & Sons Inc.

Course Title: Petroleum Fluids

Course Code: CHE610

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Study on several methods for the estimation of physical, thermodynamic and transport properties of fluids commonly used in industry. Study of literature sources where property information is available. Application of these properties to process design is emphasized to give the students a complete picture of the use and importance of good property estimation.

Course Contents:

This unit covers properties of natural gases and crude oils; fluid phase behavior; vapor—liquid equilibria; equations of state—theory; equations of state—applications; PVT laboratory experiments; petroleum fluid characterization; petroleum product specifications; surface separations; introduction to HYSYS process modeling software; H2O/hydrocarbon phase behavior; and introduction to PVT phase behavior software.

Reference Books:

1. Michael J. Moran, Fundamentals of Engineering Thermodynamics, (1992), (2nd ed.), John Wiley & Sons Inc.
2. YVC Rao, Chemical Engineering Thermodynamics, (2008), Universities Press India.
3. J. B. Jones, R.E. Dugan, Engineering Thermodynamics, (1995), (1st ed.), Prentice Hall.

Course Title: Combustion Engineering

Course Code: CHE611

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide deep understanding of combustion phenomena and apply this knowledge to recover useful work from energy while abating the associated pollutant emissions.

Course Contents:

This course provides in depth knowledge of combustion and its thermo-chemistry, combustion kinetics and laminar flame propagation, detonation and explosions, flammability and ignitions, combustion theory and modeling, combustion technology, dynamic modeling of combustion, design of combustors, environmental and safety aspects of combustion.

Reference Books:

1. Gary L. Borman & Kenneth W. Ragland, Combustion Engineering, (1998), McGraw Hill.
2. Irvin Glassman, Combustion, (3rd ed.), (1996), Academic Press.
3. N. A. Chigier & and H. H. Chiu, Mechanics and Combustion of Droplets and Sprays, (1995), Begell House, New York.
4. R. M. Fristrom, Flame Structure and Processes, (1995), Oxford.
5. Amable Linan & Forman A. Williams, Fundamental Aspects of Combustion, (1993), Oxford.
6. Kenneth Kuan-yun Kuo, Principles of Combustion, (1986), Wiley.
7. F. J. Weinburg, Advanced Combustion Methods, (1986), Academic Press, New York.
8. A. Murty Kanury, Introduction to Combustion Phenomena, (4th ed.), (1985), Gordan & Breach Science, New York.
9. F. A. Williams, Combustion Theory, (2nd ed.), (1985), Benjamin Cummings Publishing Co.
10. R. A. Strehlow, Combustion Fundamentals, (1984), McGraw Hill.

Course Title: Life Cycle Analysis

Course Code: CHE620

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Understand in depth the methodology for evaluating the environmental performance of a product, process, or activity throughout its entire existence from raw materials acquisition to ultimate disposition.

Course Contents:

The concept of life cycle and its stages with strategic goals of local and global pollution prevention. Systematic planning and performing cradle to grave evaluation of all industrial materials and activities with industrial mock studies.

Reference Books:

1. G. Tchobanoglous, Franklin, L. Burton, H. D. Stensel, Wastewater Engineering: Treatment and Reuse, (2003), (4th ed.), McGraw-Hill.
2. P. Aarne Vesilind, Wastewater Treatment Plant Design, Water Environment Federation and IWA Publishing.
3. Life cycle assessment ISO standards.

Course Title: Industrial Environmental Biotechnology

Course Code: CHE621

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of this course is to develop a sound technical foundation for evaluating the appropriateness of using biotechnology, including bioremediation and phytoremediation, for industrial waste treatment. It includes the understanding of biological mechanisms, health risk posed by major groups of environmental contaminants.

Course Contents:

Current applications of biotechnology to environmental, quality evaluation, monitoring, and remediation of contaminated environments, technology ranges from the molecular to macrobiotic, microbial removal and degradation of organics, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment, processes, biofilms/biofilters for vapor-phase wastes, and composting, modeling and design, advantages and disadvantages of applications, case studies in the areas of biosensors in environmental analysis, molecular biology applications in environmental, engineering, and genetic engineering of organisms for bioremediation.

Reference Books:

1. Bruce Rittmann, Perry McCarty, Environmental Biotechnology: Principles and Applications, (2000), McGraw-Hill, ((1st ed.)).
2. A.Vallero, Environmental Biotechnology: A Biosystems Approach, (2010), Daniel Academic Press.
3. Hans-Joachim Jördening, Environmental Biotechnology: Concepts and Applications, (2004), Josef Winter (Editor), Wiley.

Course Title: Advanced Biochemical Engineering

Course Code: CHE630

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course serves as an introduction to biochemical and microbiological applications for commercial and engineering processes, including industrial fermentation, enzymology, ultra filtration, food and pharmaceutical processing and resulting waste treatment. Enzyme kinetics, cell growth, energetic and mass transfer.

Course Contents:

This course focuses on the interaction of chemical engineering, biochemistry, and microbiology. Mathematical representations of microbial systems are featured of this subject. It includes the Kinetics of growth, death, and metabolism. Continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, and enzyme technology round out the subject material.

Reference Books:

1. Shigeo K., F. Yoshida, Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists, (2009), Wiley-VCH.
2. Douglas S. Clark and Harvey W. Blanch, Biochemical Engineering (Chemical Industries), (1997), (1st ed.), CRC Press.
3. James Bailey, Biochemical Engineer Fundamentals, (1988), (2nd ed.), McGraw Hill Higher Education.

Course Title: Bio-Chemical and Food Technology

Course Code: CHE631

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course covers the principles and applications of biochemical engineering components and methods for the analysis, design, operation, and monitoring of biochemical and food technology processes and reactors.

Course Contents:

This course focuses on the interaction of chemical engineering, biochemistry, microbiology and mathematical representations of microbial systems Biochemical processes, thermodynamics, and kinetics are used in the application of technology principles to analyze, design, and develop processes using biocatalysts. Processes of interest include those that are involved in the formation of desirable compounds and products or in the transformation, or destruction of unwanted or toxic substances.

Reference Books:

1. Shuler, Michael L., Fikret Kargi, Bioprocess Engineering: Basic Concepts, (2001), (2nd ed.), Prentice Hall PTR.
2. BLANCH, H. W., CLARK, D. S., Biochemical Engineering, (1997), Marcel Dekker Incorporated, New York.
3. Bailey, James E., David F. Ollis, Biochemical Engineering Fundamentals, (1986), McGraw-Hill Education.

Course Title: Biotechnology and Environmental Processes

Course Code: CHE632

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of this course is to develop a sound technical foundation for evaluating the appropriateness of using biotechnology, including bioremediation and phytoremediation, for environmental cleanup. It includes the understanding of biological mechanisms, health risk posed by major groups of environmental contaminants.

Course Contents:

This course focuses current applications of biotechnology to environmental quality evaluation, monitoring, and remediation of contaminated environments. The scale of technology ranges from the molecular to macrobiotic. It also covers the microbial removal and degradation of organics, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment processes, biofilms/biofilters for vapor-phase wastes, and composting. Emphasis will be placed on modeling and design. Advantages and disadvantages of each application are compared. Case studies are presented in the areas of biosensors in environmental analysis, molecular biology applications in environmental engineering, and genetic engineering of organisms for bioremediation.

Reference Books:

1. Bruce Rittmann, Perry McCarty, Environmental Biotechnology: Principles and Applications, (2000), (1st ed.), McGraw-Hill.
2. Daniel A. Vallero, Environmental Biotechnology: A Biosystems Approach, (2010), (1st ed.), Academic Press.
3. Hans-Joachim J., Josef Winter, Environmental Biotechnology: Concepts and Applications, (2004), Wiley.

Course Title: Industrial Polymer Chemistry

Course Code: CHE640

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide in-depth knowledge of the most timely and extensively researched areas of polymer chemistry. All the topics aim at producing novel, functional and advanced polymer materials. Students will be introduced about different polymer industry, processes involved during the production.

Course Contents:

Introduction to polymers (size, properties, nomenclature), Step-growth polymerization (nylons, polyesters, polycarbonates), Radical chain polymerization (polystyrene, polyacrylates, PVC), Ionic polymerizations (polystyrene, poly(vinyl ethers), synthetic rubber), Living polymerization (towards monodisperse macromolecules), Coordination polymerization (polyethylene, polypropylene), Ring-opening polymerization (polylactide, poly(ethylene oxide), Advanced polymeric materials (conducting polymers, block copolymers).

Reference Books:

1. Hiemenz and Lodge, Polymer Chemistry, (2007), (2nd ed.), CRC Press.
2. Odian, Principles of Polymerization, (2004), (4th ed.), Wiley.
3. Young, Lovell, Introduction to Polymers, (1991), (2nd ed.), CRC Press.

Course Title: Rubber and Plastics Materials

Course Code: CHE641

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course is aimed at providing the students with knowledge of the rubber and plastic materials. Most of the topics deal with the latest developments in these materials.

Course Contents:

Rubber: Natural Rubber, Synthetic Rubber, Rubber Manufacturing Processes Compounding of Rubber Vulcanized Rubber Critical examination of new elastomers and thermoplastic elastomers appearing in the current research literatures. Studies of new elastomers and thermoplastic elastomers in terms of their compositions, morphology, properties, and applications. Innovation of fabrication process for new elastomers and thermoplastic elastomers, Thermo Plastic and Thermosetting Plastic, Description of Plastics materials, Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft, Polyolefins, Vinyl Chloride polymers, Acrylic plastics, Styrene based plastics, Poly(vinyl acetate) based plastics,

Reference Books:

1. K. Haghi, Eduardo A. Castro, Sabu Thomas, P. M. Sivakumar, Andrew G. Mercader, Materials Science of Polymers: Plastics, Rubber, Blends and Composites Apple Academic Press, (2015).
2. M. Blow, Rubber Technology and Manufacture, (1982), (2nd ed.), Butterworth London.
3. Werner, H., Rubber Technology Handbook, (1996), Hanser Publication, NY.

Course Title: Composite Materials

Course Code: CHE642

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide thorough treatment of the classification and properties of composite materials. Different methods of manufacturing and analysis will be the part of this course.

Course Contents:

Introduction to polymeric materials and their classification. Need of Blends and Composites. Applications and production methods for composites. Classification of composites on the basis of different fillers. Testing and Characterization of composites

Reference Books:

1. Strong Bent A., Fundamentals of Composites Manufacturing: Materials Methods and Application, (2008), Society of Manufacturing Engineering USA.
2. Vasilie Velary. V., Mechanics and Analysis of Composite Materials, (2001), Elsevier Science Ltd. UK.
3. Perters S. T., Handbook of Composites, (1998), (2nd ed.), Chapman & Hall.
4. Chawala, K. K., Composite Materials Science and Engineering, (1998), (2nd ed.), Springer USA.

Course Title: Polymer Physics

Course Code: CHE643

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Develop an understanding of structure-property relationships in polymers, C structure and properties of polymers, Characterize and design polymer processes within realistic physical constraints, Understand the societal impacts of polymer processing , Develop communication skills, Develop lifelong learning skills

Course Contents:

Introduction; hard vs. soft solids; polymerization,Molecular structure and the physical property relationships for polymers: viscoelastic behavior, the glass transition, thermomechanical and rheological properties, the crystalline and amorphous molecular solid state. Correlation of properties with design engineering of polymer applications, Diffusion of polymers; reptation; elasticity, thermodynamics of polymer solutions, Chain folding; polyethylene and nylon; spherulites.

Reference Books:

1. Young, R. J., and P. A. Lovell. Introduction to Polymers. (2nd ed.) Boca Raton, FL: CRC Press, (2000).
2. G. Strobel, The Physics of Polymers, (2007), (3rd ed.), Springer-VBH.
3. M. Rubinstein, R. H. Colby, Polymer Physics, (2003), Oxford University Press.
4. M. Doi, Introduction to Polymer Physics, (1996), , Clarendon Press.
5. P. G De Gennes, Scaling concepts in polymer physics, (1979), Cornell University Press.

Course Title: Colloid and Surfactant Science

Course Code: CHE644

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course is designed to provide up-to-date knowledge on the principles involved in colloid and interface science, as well as surfactants, and to demonstrate their relevance for solving practical problems.

Course Contents:

Introduction to theory and applications of colloidal dispersions and surfactant science. Monolayer adsorption at interfaces, electrical double layers, dispersion forces, electro-kinetic phenomena, and stabilization of dispersions. Chemistry, structure, and classification of surfactants, critical micelle concentrations, micellar solubilization, and catalysis. Detergency and wetting phenomena. Emulsion technology and applications.

Reference Books:

1. Jim W. Goodwin, Colloids and Interfaces with Surfactants and Polymers: An Introduction, (2004), John Wiley & Sons USA.
2. Kunio Esumi, Minoru Ueno, Structure Performance Relationships in Surfactants, (2003), (2nd ed.), Marcel Dekker, Inc. USA.
3. Drew Myers, Surfaces, Interfaces, and Colloids: Principles and Applications, (1999), (2nd ed.), John Wiley & Sons, Inc.USA.

Course Title: Polymer Testing

Course Code: CHE645

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The polymer testing is designed to provide in depth knowledge polymer structure property relationship, polymer testing and characterizations.

Course Contents:

Principles of material selection, Fundamental influence factors, Hybrid methods of testing, Linear elastic behavior, Linear elastic behavior and Viscoelasticity and models for description, Deformation and fracture behavior, Mechanical spectroscopy of polymers, Tensile Test and Tear test, Bend and compression test, Static testing of polymers, dynamic loading of polymers, Impact behavior of polymers, Hardness measurement of polymeric materials

Reference Books:

1. Charles A. Harper, Plastic Materials and Processes: A Concise Encyclopedia, (2003), John Wiley & Sons, Inc., Hoboken, New Jersey.
2. Kirk Cantor, Blown Film Extrusion: An Introduction, (2006), Hanser Ohio, USA.
3. R.J. Crawford, Plastic Engineering, (1998), (3rd ed.), Butterworth-Heinemann.

Course Title: Plastic Technology

Course Code: CHE646

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Plastic technology also referred as plastics engineering is based mostly on the chemical engineering as it involves designing of processes and equipment for producing new and different type of synthetic material. Students will be able to develop plastics of various types and capacities for various applications like medical automotive plastics, epoxy etc.

Course Contents:

Introduction to plastic materials, Raw materials, Difference between Polymer and Plastics, Classification of Plastics, Overview of different materials structure, properties and typical applications Typical processing conditions and characteristics, Plastic materials and application, Polymer processing Techniques, Extruded Tube, Material and product testing, Injection Molded Components.

Reference Books:

1. W. Michaeli, H. Greif, Leo W., Franz-Josef V., Training in plastics technology, (2000), (2nd ed.), Hanser Verlag.
2. Walter Michaeli, Plastics Processing:An Introduction, (1995), Hanser Publishers.
3. Manas Chanda, Plastics Technology Handbook, (2006), (4th ed.), CRC Press.
4. Nigel Mills, Plastics, Third Edition: Microstructure and Engineering Applications, (2005), (3rd ed.), Butterworth-Heinemann.

Course Title: Technology of Textile Wet Processing

Course Code: CHE650

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Student will be able to develop an approach to an insight to the basic process of wet processing which enables him to understand the basic Operation conducted in textile processing, cost involves and critical parameters associated with the process.

Course Contents:

The consumption of energy in form of water and electricity is relatively high, especially in processes like washing, de-sizing, bleaching, rinsing, dyeing, printing, coating and finishing. Processing is time consuming. The major portion of water in textile industry is used for wet processing of textile (70 per cent). Approximately 25 per cent of energy in the total textile production like fiber production, spinning, twisting, weaving, knitting, clothing manufacturing etc. is used in dyeing Introduction to the science and technology used in textile wet processing. Topics include preparation, dyeing, printing and finishing of textiles, basics of color generation and measurement. Emphasis mainly on cotton, wool, nylon and polyester.

Reference Books:

1. C. Tomasino, Chemistry & Technology of Fabric Preparation and Finishing, (1992), Dept of Textile Engg., Chemistry & Science College of Textiles NCSU.
2. G. Mock, Fundamentals of Dyeing and Printing, (1997), Raleigh, NC, . USA.

Course Title: Technical Textiles

Course Code: CHE651

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

In this course the students will learn different types of non-woven technologies & study different types of technical textiles.

Course Contents:

Definition and scope of Technical Textiles: Application of technical textiles in different fields of life such as Agriculture, Industry, Construction, Medical etc. Development in fibre materials such as polyester, polyolefin, glass, high performance fibres for special applications in different technical products. Technical products for automobiles: Seat belt system, Air bag system, Car interiors. Materials used Manufacturing techniques and testing methods. Protective Clothing; Ballistic body protection, Protection against heat and flame, Cold protective clothing, Physiological functions and parameters, Material used such as phase change material, manufacturing techniques and testing methods.

Reference Books:

1. John Shore, Cellulosic Dyeing, (1995), Society of Dyers and Colorists.
2. Jose Cegarra, Dyeing of Textile Materials, (1992), Textilia.
3. W.C. Miles, Textile Printing, (2003), Society of Dyers & Colorists.
4. Derek Heywood, Textile Finishing, (2003), Society of Dyers & Colorists.

Course Title: Pre-Chemical Treatment Processes of Textile

Course Code: CHE652

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Learning outcomes will understand of various processes involved in the textile processes so that Standard operating procedures should be devised to maintain a steady quality control and process parameters.

Course Contents:

include different kinds of fibers, how to prepare fibers before any treatment, Desizing of synthetic fibers and there blends ,Scouring (mechanism of removing impurities ,Different Machineries involved in scouring ,Bleaching of textiles and different machineries used for bleaching ,Heat settings ,Mercerizing ,OBA ,Combined pretreatment processes of textiles ,Conservation of energy and water in pretreatment ,Analysis and testing in preparatory processes.

Reference Books:

1. S. R. Karmakar, Chemical Technology in the pretreatment of textiles, Textile sciences and technology, (1999), Elsevier Science.

Course Title: Processes for Cotton Dyeing

Course Code: CHE653

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

In this course the students will study in detail the principles and practice of dyeing natural, regenerated, and manmade fibres and their blends. The students will study classification, chemical structure, dyeing by batch, semi-continuous and continuous dyeing methods and overview of the machinery involved. The course also covers theory of dyeing, dyeing machinery and most common problems encountered in case of dyeing with different dyes by different dyeing methods, and their preventative and corrective measures.

Course Contents:

Cotton Fibers and Blends: The origin and production of cotton fibres, factors determining its length, fineness and strength, morphology of cellulose macromolecules, structural characteristics of cellulose fibres for dyeing. Purpose of blending cotton fibres, modification in the properties of cotton fibers caused by the blending, effects of blending on the dyeing properties of fibres. Dyeing Processes of Cotton and Its Blends: Processes and Machines related to the dyeing process of cotton and its blends, principals of batch wise dyeing, exhaust dyeing, semi continuous dyeing, and continuous dyeing. Semi continuous Dyeing of Cotton and Its Blends: Methods of discontinuous dyeing, Types of machine used, Processing technologies (processing conditions and parameters affecting the quality of dyeing. Tests for the process quality Continuous Dyeing of Cotton and Its Blends: Methods of continuous dyeing. Thermosol dyeing of cotton and polyester, Types of machine used for continuous and thermosol dyeing. Steaming and washing processes. Processing technologies (processing conditions and parameters affecting the quality of dyeing. Tests for the process quality. Dyes for Cotton: Dyes for cotton fibres, basic chemical structure, dyeing properties and their relation with the chemical structure and properties Chemical Auxiliaries in Dyeing of Cotton: Explaining the use of auxiliary chemicals used in the dyeing of cotton and its blends with polyester, viscose and other cotton blend used in national textile industry.

Reference Books:

5. Jose Cegarra, Dyeing of Textile Materials, (1992), Textilia.
6. Gohl, E. P. G. and Vilensky, L. D Textile science, (1983), (2nd ed.) Longman Cheshire Limited, Melbourne.
7. S.M. Burkinshaw, Chemical Principles of Synthetic Fibre Dyeing, (1995), Chapman and Hall, London.

Course Title: Textile Printing

Course Code: CHE654

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

In this course students will study principles and practice of different methods and styles of printing including block printing, flat screen printing, rotary screen printing, direct style, resist style, discharge style, burn-out printing, flock printing, transfer printing and ink-jet printing. The course covers print design studio, screen making, print past preparation & rheology, printing process and fixation. The students learn printing of fabrics of natural, manmade and blended fibers with pigments and other dyestuffs, role of auxiliaries and the working principles of machinery used for printing and fixation.

Course Contents:

Pigment Printing: Pigment printing background, pigments, pigment dispersion and its production. Binder systems, chemical nature of binders, cross- linking, effects of binder on print and fabric. Thickening systems- types of thickening systems (emulsion based o/w and w/o emulsions; and fully aqueous systems). Explaining the advantages and disadvantages of pigment printing. Preparation and Properties of Print Paste. Equipment used characteristics of pigment print paste. Rheology and viscosity, measurement of viscosity. Pigment print as head colour, and ground colour in discharge and resist printing technique. Machines for Textile Printing: Elaborating the elements, including belt and adhesive system, screen drives, squeegee systems, and speed, for the Rotary screen printing machine and flat belt printing machine. Reactive and Disperse Dye Printing: Available range of dyestuffs, comparison and limitations of dyestuffs, effects and properties of printed fabric using various dyes, discharge and resist printing. Thickener Systems: Choice of thickener system, properties, merits and effects on quality of printed fabric. Printing Methods and Procedures: Principals for the use of all- in method and two-stage method for the printing of cotton, and the associated effects on the print quality. Methods for the printing of cotton blends. Dry heat fixation and steam fixation techniques for the printing of cotton and its blends. Effects of drying time, temperature and steaming conditions on the quality of printed fabric. Types of washing processes, washing processes for the printed cotton and its blend for various dyestuffs.

Reference Books:

1. W.C. Miles, Textile Printing, (2003), Society of Dyers and Colorists.
2. V.A. Shenai, Technology of Printing, (1990), Society of Dyes and Colorists.

Course Title: Plasma Chemical Engineering

Course Code: CHE678

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To integrate fundamental knowledge of chemical engineering, plasma physics and plasma chemistry to enable students to design plasma reactors for chemical synthesis

Course Contents:

Introduction to plasma, field equations, conservation equations, Boltzmann's equation, Debye shielding, Debye length, plasma sheath, collisions in plasmas, types of collisions, elementary reactions in plasma, LTE and non-LTE plasmas, breakdown processes in non-LTE plasmas, types of plasmas, atmospheric pressure glow discharges, Corona discharges, Dielectric barrier discharges, capacitively coupled plasmas, arc discharges, micro-discharges, Current-Voltage characteristics of DC and AC powered plasmas, Townsend mechanism of electrical breakdown, spark breakdown mechanism, Paschen curve, plasma- chemical kinetics, kinetics of O3 formation, Kinetics of H2 formation, plasma power supplies, impedance matching network, plasma diagnostics, plasma reactor design, plasma micro-reactors, ozone generator

Reference Books:

1. Goldstone R. J., & Rutherford P.H., (1995), Introduction to Plasma Physics, IOP publishing.
2. Fridman, A. A. & Kennedy, L. A. (2004). Plasma physics and engineering, CRC.
3. Lieberman, M. A. & Lichtenberg, A. J. (2005). Principle of Plasma Discharge and Material Processing, John Wiley & Sons, Inc.
4. Bellan, P. M. (2006). Fundamentals of plasma physics, Cambridge University Press.
5. Fridman, A. A. (2008). Plasma chemistry, Cambridge University Press.

Course Title: Emerging Topics in Chemical Engineering

Course Code: CHE690

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide a comprehensive review and reinforcement of foundational chemical engineering concepts, preparing students with a strong theoretical and practical background for advanced interdisciplinary research.

Course Contents:

Thermodynamics: Principles of thermodynamics, first and second laws, energy balances, thermodynamic cycles, equilibrium and phase transformations. Kinetics: Chemical reaction kinetics, reaction mechanisms, rate laws, catalysis, reactor design. Transport Phenomena: Mass, heat, and momentum transfer, diffusion, convection, conduction, boundary layer theory, and separation processes. Reaction Engineering: Chemical reactors, ideal and non-ideal reactors, residence time distribution, conversion and selectivity, optimization. Separation Processes: Distillation, absorption, adsorption, extraction, membrane separation, chromatography. Process Control and Instrumentation: Basic principles of process control, feedback, and feedforward control systems, PID controllers, process analysis and modeling, and instrumentation for process monitoring and control. Chemical Plant Design: Process design principles, material and energy balances, equipment selection and sizing, process safety and economics.

Reference Books:

1. Whitaker, S. (2023). *Fundamentals of transport phenomena in porous media* (5th ed.). Springer International Publishing.
2. Richardson, J. F., & Peacock, D. G. (2023). *Coulson and Richardson's chemical engineering* (Vol. 6, *Chemical engineering design*). Butterworth-Heinemann.
3. Levenspiel, O. (2023). *Chemical reaction engineering* (4th ed.). Wiley-Blackwell.
4. Smith, J. M., & Van Ness, H. C. (2022). *Chemical engineering thermodynamics* (9th ed.). McGraw-Hill.
5. Fogler, H. S. (2020). *Elements of chemical reaction engineering* (6th ed.). Pearson Education Limited.
6. Walas, S. M. (2021). *Chemical process engineering* (3rd ed.). Gulf Professional Publishing.
7. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2020). *Transport phenomena* (2nd ed.). John Wiley & Sons.

Course Title: Integrative Approaches to Chemical Engineering Research

Course Code: CHE695

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To introduce students to the exciting world of interdisciplinary research in chemical engineering, equipping students with the knowledge, skills, and strategies to navigate collaborations and tackle complex problems across disciplines.

Course Contents:

Introduction to Interdisciplinary Research: Concept of interdisciplinary research, challenges and opportunities in interdisciplinary research, successful case studies of interdisciplinary collaborations. Fundamentals of Different Disciplines: Guest lectures from faculty in relevant interdisciplinary fields (e.g., materials science, biotechnology, environmental engineering) providing basic overviews of their respective fields and potential collaboration areas. Interdisciplinary Research Methods: Design thinking, problem-solving frameworks, data analysis and visualization for complex datasets, communication and collaboration skills for diverse teams. Project Work: Collaborative interdisciplinary research projects on real-world problems, requiring students to utilize their chemical engineering knowledge and integrate other disciplinary perspectives.

Reference Books:

1. Cottrell, S., & Newman, H. (2022). *Interdisciplinary research: Theory and practice* (4th ed.). Routledge.
2. Genz, S. J. (2021). *The art and science of interdisciplinary research*. SAGE Publications.
3. Hazen, R. M., & Reed, P. (2021). *How science works: Five principles for scientific discovery*. Basic Books.
4. Klein, J. T. (2020). *Interdisciplinary problem solving: Building bridges between disciplines*. Springer International Publishing.
5. Morley, M., & Campbell, A. (2021). *Interdisciplinary research: Theory and practice*. University of Toronto Press.
6. Frodeman, R. (2020). *Handbook of research collaboration: Working with scientists, engineers, and practitioners* (2nd ed.). Edward Elgar Publishing.
7. Gibbons, A. (2020). *A short history of nearly everything*. Knopf Doubleday Publishing Group.

Course Title: Dimensionless Groups: Advanced Applications and Techniques in Chemical Engineering

Course Code: CHE696

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To critically evaluate and synthesize advanced theories related to dimensionless groups in Chemical Engineering. To analyze and interpret complex dimensionless groups in the context of transport phenomena, reaction engineering, and separation processes. To apply advanced dimensionless groups to address contemporary challenges and optimize chemical processes at an expert level. To conduct independent research, utilizing dimensionless groups as a fundamental tool for theoretical analysis and experimental design. To communicate effectively, both orally and in writing, about advanced concepts and applications of dimensionless groups in Chemical Engineering.

Course Contents:

Advanced Concepts in Dimensionless Groups: Exploration of recent developments in dimensionless groups and their significance in scaling and modeling complex physical systems. Advanced applications of the Buckingham Pi Theorem for identifying and formulating dimensionless groups in intricate engineering problems. Advanced Transport Phenomena Analysis: In-depth examination of complex dimensionless groups such as Reynolds number, Nusselt number, Prandtl number, Schmidt number, and Sherwood number. Advanced application of dimensionless groups in analyzing intricate flow patterns, heat and mass transfer rates, and reactor design optimization. Cutting-edge Research in Reaction Engineering: Advanced discussions on Damkohler numbers (I, II, III) and their intricate relation to reaction kinetics and reactor performance. Exploration of advanced dimensionless groups in catalytic processes, including Thiele modulus and effectiveness factor, for reactor design and optimization. Advanced Separation Processes Analysis: Advanced examination of dimensionless groups such as Reynolds number, Schmidt number, Peclet number, and their significance in various separation techniques like distillation, extraction, and chromatography. Advanced application of dimensionless groups in analyzing separation efficiency, optimizing process parameters, and scaling-up separation equipment.

Reference Books:

1. Datta, A. K. (2023). *Dimensionless groups in transport phenomena* (2nd ed.). Cambridge University Press.
2. Furlong, C. T. (2023). *Scaling chemical engineering processes: From research to production* (2nd ed.). CRC Press.
3. McComb, W. H. (2021). *A practical guide to dimensional analysis and similarity in engineering*. Springer.

4. Gerhold, K. J. (2020). *Introduction to chemical engineering: Principles and practice* (4th ed.). Wiley.
5. Hansen, C. (2020). *Process modeling and simulation: Computer-aided design of chemical and biochemical processes* (4th ed.). Elsevier.
6. Levenspiel, O. (2020). *Chemical reaction engineering* (4th ed.). Wiley-Blackwell.
7. Brodkey, R. S., & Hershey, H. C. (2020). *Transport phenomena in chemical engineering* (2nd ed.). McGraw-Hill.

Course Title: Advanced Reaction Engineering

Course Code: CHE697

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides an advanced understanding of chemical reaction engineering principles and their applications. It covers detailed reaction kinetics, reactor design, and analysis for complex chemical systems, equipping students with the necessary skills for research and development in chemical engineering.

Course Contents:

Review of Basic Reaction Kinetics: Elementary and non-elementary reactions. Rate laws and reaction mechanisms. Complex Reaction Mechanisms: Chain reactions, polymerization, and biochemical reactions. Determining reaction pathways and rate-limiting steps. Kinetics of Catalytic Reactions: Langmuir-Hinshelwood and Eley-Rideal mechanisms. Surface reaction kinetics and adsorption isotherms. Ideal Reactor Design and Analysis of Batch Reactors: Advanced design equations. Scale-up considerations and applications. Continuous-Flow Reactors: Detailed analysis of CSTR and PFR. Design for complex reactions and multi-phase systems. Reactors in Series and Parallel: Optimization of reactor networks. Yield and selectivity considerations. Non-Ideal Reactor Design Residence Time Distribution (RTD) Theory: Detailed RTD function and its significance. Application of RTD in diagnosing reactor performance. Models for Non-Ideal Reactors: Dispersion model, tank-in-series model, and compartment models. Computational fluid dynamics (CFD) approaches. Effects of Non-Ideal Flow on Reactor Performance: Mixing and segregation. Impact on conversion and selectivity. Catalysis and Catalytic Reactors Advanced Catalysis Concepts: Catalyst design and preparation. Characterization of catalysts. Heterogeneous Catalytic Reactors: Fixed-bed and fluidized-bed reactor design. Catalytic deactivation and regeneration. Kinetics of Biocatalysts: Enzyme kinetics and immobilized biocatalysts. Design of bioreactors for enzymatic reactions. Multiphase Reaction Systems Gas-Liquid Reactions: Absorption with chemical reaction. Design of bubble column and slurry reactors. Gas-Solid Reactions: Diffusion and reaction in porous catalysts. Design of packed bed and fluidized bed reactors. Liquid-Liquid and Solid-Liquid Reactions: Mass transfer and reaction in multiphase systems. Design considerations for extraction and leaching reactors. Advanced Topics in Reaction Engineering Microreactors and Process Intensification: Principles of micro-reaction technology. Design and applications of microreactors. Reactive Distillation and Other Integrated Processes: Combining reaction and separation processes. Design and optimization of reactive distillation columns. Sustainability and Green Chemistry: Design of sustainable chemical processes. Catalysis and reaction engineering for green chemistry.

Reference Books:

1. Fogler, H. S. (2020). *Elements of chemical reaction engineering* (6th ed.). Prentice Hall.
2. Smith, J. M. (2001). *Chemical engineering kinetics* (3rd ed.). McGraw-Hill Book Co.
3. Levenspiel, O. (1999). *Chemical reactor engineering* (2nd ed.). John Wiley & Sons.

Course Title: Advanced Heat and Mass Transfer Operations

Course Code: CHE698

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides an in-depth understanding of advanced concepts in heat and mass transfer. It covers detailed mechanisms, mathematical modeling, and practical applications of heat and mass transfer operations, preparing students for research and development in chemical engineering.

Course Contents:

Review of Basic Heat Transfer Concepts: Conduction, convection, and radiation. Conduction Heat Transfer: Advanced steady and unsteady-state conduction. Anisotropic and composite materials. Solutions to complex geometries using analytical and numerical methods. Convection Heat Transfer: Boundary layer theory. Turbulent convection. Heat transfer in high-speed flows. Applications in heat transfer enhancement techniques. Radiation Heat Transfer: Radiative properties of real surfaces. Radiative exchange in enclosures with participating media. Advanced methods for solving radiative heat transfer problems. Review of Basic Mass Transfer Concepts: Molecular and convective mass transfer. Diffusive Mass Transfer: Multicomponent diffusion. Diffusion in porous media. Diffusion in biological systems. Convective Mass Transfer: Mass transfer in turbulent flows. Mass transfer with chemical reaction. Mass transfer in multiphase systems. Mass Transfer in Membranes: Membrane transport theory. Applications in separation processes (reverse osmosis, gas separation). Heat and Mass Transfer with Phase Change: Evaporation and condensation: mechanisms and modeling. Design of condensers and evaporators. Boiling and condensation heat transfer: pool and flow boiling. Condensation on different surfaces. Solid-Liquid Phase Change: Melting and solidification. Applications in materials processing and thermal energy storage. Heat and Mass Exchangers: Design and analysis of heat exchangers. Advanced methods for design and optimization. Heat exchanger networks. Mass Exchangers: Design and analysis of packed and tray columns. Applications in absorption, stripping, and extraction. Computational Methods in Heat and Mass Transfer: Numerical methods for heat transfer: finite difference, finite volume, and finite element methods. Use of software tools (e.g., ANSYS, FLUENT, COMSOL). Numerical Methods for Mass Transfer: Solution of mass transfer equations using numerical techniques. Applications in complex geometries and boundary conditions. Computational Fluid Dynamics (CFD): Introduction to CFD. Applications of CFD in heat and mass transfer problems.

Reference Books:

1. Cengel, Y. A., & Ghajar, A. J. (2014). *Heat and mass transfer: Fundamentals and applications* (5th ed.). McGraw-Hill Education.
2. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). *Unit operations of chemical engineering* (7th

ed.). McGraw-Hill.
3. Coulson, J. M., & Richardson, J. F. (2002). *Chemical engineering* (Vol. 2, 5th ed.). The English Book Society and Pergamon Press.
4. Incropera, F. P., & DeWitt, D. P. (1990). *Fundamentals of heat and mass transfer* (3rd ed.). John Wiley & Sons.
5. Treybal, R. E. (1981). *Mass-transfer operations*. McGraw-Hill Book Company.
6. Schweitzer, P. A. (1979). *Handbook of separation techniques for chemical engineers*. McGraw-Hill Book Co.
7. Coulson, J. M., & Richardson, J. F. (1999). *Chemical engineering* (Vol. 1). The English Book Society and Pergamon Press.

Course Title: Advanced Treatment of Simultaneous Heat and Mass Transfer

Course Code: CHE700

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course is to focus on the advanced studies of heat and mass transfer with emphasis on their analysis and applications to practical engineering problems. Use of computational tools for the analysis of industrial problems involving heat and mass transfer will be employed in this course.

Course Contents:

Identify and analysis thermal processes involving heat conduction, convection and radiation and Mass transfer by molecular diffusion, Integrate fundamental principles of heat and mass transfer with quantitative analysis to solve engineering problems, problems related to various types of distillation including Multi component, Batch, Steam, Azeotrpic, extractive distillation, Crystallization, Membrane separation, Transport properties, conservation equations, conduction heat transfer, convective heat and mass transport in laminar and turbulent flows, phase change processes, thermal radiation.

Reference Books:

1. Kern Donald Q. Process Heat Transfer, (1997), McGraw Hill Book Company.
2. Cengel Yunus A. Heat Transfer-A Practical approach, (1988), McGraw Hill Book Company.
3. Incropera Frank P., De Witt David P. Fundamentals of Heat and Mass Transfer (5rd ed.) (2002). John Wiley and Sons.
4. Coulson J.M., Richardson J.F. Chemical Engineering Vol-I, (1999). The English Book Society and Pergamon Press.
5. Coulson J.M., Richardson J.F. Chemical Engineering Vol-II, (5th ed.) (2002). The English Book Society and Pergamon Press.
6. J. P. Holman, Heat Transfer, (2002), McGraw Hill Book Company.
7. MeCabe Warren L., Smith Julian C., Harriott peter Unit Operations of chemical Engineering (7th ed.) (2005). McGraw Hill Inc.
8. Schweitzer, Handbook of Separation Techniques for Chemical Engineers, (1979), McGraw Hill Book Co.
9. Pergamon Press Alan S.Foust, Leonard A.Wenzel Principles of Unit Operations (2nd ed.)(1980). John Wiley & Sons.

Course Title: Computational Fluid Dynamics

Course Code: CHE701

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The aim of this unit is to provide students with physical significance of each term in the governing equations for CFD, quantify & analyze the numerical error in solution of the CFD and solve practical CFD problems.

Course Contents:

Study of approaches including time accurate and steady-state methods, explicit and implicit techniques, Eulerian and Lagrangian methods, laminar and turbulent flow, compressible and incompressible approaches, projection methods, stability considerations, etc. Applications of CFD to mixing, heat transfer and reaction.

Reference Books:

1. J. H. Ferziger & M. Peric, Computational Methods for Fluid Dynamics, ((3rd ed.)), Springer, Berlin, Heidlberg, New York, (2002). ISBN 3-540-42074-6.
2. John D. Anderson, Computational Fluid Dynamics, The Basics with Applications, the Basics with Applications, (1995), McGraw Hill.
3. Pieter Wesseling, Principles of Computational Fluid Dynamics, Springer, Berlin, Heidlberg,, (1991), New York.
4. R. B. Bird, W.E. Stewart, and E.N. Lightfoot, Transport Phenomena, (1960), John Wiley and Sons.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere, (1980), New York.

Course Title: Advanced Catalytic Processes

Course Code: CHE702

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop thorough understanding of new and developed catalytic processes practiced in petroleum refining & processing, biochemical processing and environmental processes.

Course Contents:

Role of the catalyst in terms of nature of active sites, thermodynamic consideration and adsorption-desorption aspects. Heterogeneous eliminations, additions and substitutions, General principles of catalytic hydrogenation, catalytic hydrogenation of olefins, alkynes, alkadienes and cyclic molecules, Heterogeneous oxidation of olefins and aromatics, Catalytic decomposition: catalytic cracking, hydro-cracking, hydrogen steam reforming, Catalytic unification: alkylation, polymerization, Catalytic Alteration: reforming, isomerisation, Catalytic treatment processes: hydrodesulphurization, hydro treating, sweetening, Fuel Cells, Catalytic combustion process, heterogeneous photo catalysis, enzymatic and polymerization catalytic process, mono and bimetallic catalytic processes, membrane catalysis, nanostructured metals catalytic processes.

Reference Books:

1. Robert J. Farrauto. Fundamentals of industrial catalytic processes, 2nd revised edition, (2005), John Wiley and Sons.
2. C. H. Bamford, Charles Frank Howlett, Complex catalytic processes, (2004), Elsevier Science.

Course Title: Fluidization Engineering

Course Code: CHE703

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide detailed knowledge of fluidization process with emphasis on properties & parameters governing the design of fluidized systems including fluidized bed reaction, gasification and combustion.

Course Contents:

Introduction to fluidization, Solid movement, Mixing, segregation, Particle to gas mass transfer, Particle to gas heat transfer, Fluidization Velocity, Elutriation and entrainment, Effect of Temperature and Pressure Fluid flow through the bed and pressure drop calculation, Fluidized Bed Scale-up, Two phase particle bed model, Fluidization systems: Dense Bed Fluidization, Bubbling Bed Fluidization, High Velocity Fluidization, Circulating Bed fluidization, Liquid Solid Fluidization, Three Phase Fluidization, Fluidization system design: Fluidized Bed Combustor/ Fluidized Bed Gasifier/ Fluidized Bed Reactor, Application of Fluidization.

Reference Books:

1. Jonghwun Jung, Design and Understanding of Fluidized Bed Reactors, (2009), VDM Verlag McGraw Hill.
2. L G Gibilaro, Fluidization Dynamics, (2001), Publisher: Butterworth-Heinemann.
3. O Molerus, Heat Transfer in Fluidized Beds Book, (1997), Wirth, K E Wirth, Chapman & Hall, McGraw Hill.
4. Simeon N Oka, E J Anthony, Fluidized Bed Combustion, (2003), CRC Press.
5. Prabir Basu, Combustion and Gasification in Fluidized Beds, (2006), CRC Press.
6. Octave Levenspiel, Fluidization Engineering, (1991), Second edition, Imprint: Butterworth Heinemann, McGraw Hill.

Course Title: Novel Separations

Course Code: CHE704

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To impart knowledge of latest separation techniques so that the students may integrate these techniques in existing and hereafter industrial ventures.

Course Contents:

Membrane separation systems: per-vaporation processes, organic solvent nano-filtration, electro-membrane processes, friction-diffusion separation process, hybrid separation systems: reactive distillation, reactive extraction, solvent stripping, reactive rectification, Melt crystallization, Ligand exchange separation technique, combined ion-exchange solvent extraction separation technique, super critical fluid extraction, chromatography, electrophoresis, superconducting magnetic separation technique, hybrid separation techniques, gas carrying evaporation.

Reference Books:

1. Suzana Pereira Nunes, Membrane technology in the chemical industry, (2007), Klaus-Viktor Peinemann.
2. C.A. Costa and Joaquim Chromatographic and Membrane Processes in Biotechnology by S. Cabral, (1991), McGraw Hill.
3. Norman Li, Separation and Purification Technology, (1992), McGraw Hill.
4. Peter R. Keller Membrane technology and industrial separation techniques, (1976), McGraw Hill.

Course Title: Oil and Gas Economics

Course Code: CHE710

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Students will have the understanding of economic aspects in oil and gas sector; develop concept of cash flow management; risk and asset management.

Course Contents:

This unit covers the oil and gas industry from an economic perspective; international industry structure; Australian industry structure; oil and gas industry in Western Australia; the economics of investment; discounted cash flow analysis; cost–benefit analysis; internal rate of return; oil and gas markets; supply and demand determining prices and output; prices and non-renewable resources—hotelling principle; the operation of cartels; dealing with risk in oil and gas markets; open access to natural gas pipelines; natural monopoly theory; national competition policy; gas market regulation; taxation of the oil and gas industry; concept of economic rent; Commonwealth and state royalty systems; resource rent tax; oil and gas industry and the Australian economy; impact and multiplier analysis; balance of payments and exchange rate effects; government policy and the oil and gas industry; the greenhouse gas issue; and tradeable emissions permits.

Reference Books:

1. Seider, W.D., Seader, J.D. and Lewin, D.R. Process Design Principles - Synthesis, Analysis and Evaluation, (1999), John Wiley and Sons Inc.
2. Biegler, L.T., Grossmann, I.E., and Westerberg, A.W. Systematic Methods for Chemical Process Design, (1997), Prentice-Hall.
3. Smith, R. Chemical Process Design, (1995), McGraw-Hill.
4. Peters, M.S. and Timmerhaus, K.D. Plant Design and Economics for Chemical Engineers, (1980), McGraw-Hill.
5. Douglas, J.M. Conceptual Design of Chemical Processes, (1988), McGraw-Hill.

Course Title: Surface Petroleum Operations

Course Code: CHE711

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of this course is to provide the understanding of the processes applied to the fluid produced at the well head in the preparation for transportation or storage. Process Engineer is faced with mixture of oil, gas and water as well as small volumes of undesirable substances which have to be separated and treated for export.

Course Contents:

Processing of crude oil and the associated natural gas of the wellhead into stabilized crude oil, pipeline quality natural gas, natural gas liquids and sulfur. Gas-oil separation, crude oil desalting, gas sweetening and dehydration, recovery and fractionation of natural gas liquids, sulfur production and crude oil stabilization. Computer simulation of major oil field processes. Thermodynamics and phase equilibria of multi-component hydrocarbon mixtures. Gas compression, refrigeration and two-phase flow.

Reference Books:

1. G.V. Chinlingarian., J.O. Robertson. JR. Sanjay Kumar, Surface operation in petroleum production, (1987), CRC Press.
2. Frank Jahn, Mark Cook, Mark Graham, Hydrocarbon exploration and production, ((2nd ed.)), (2008), MacGraw Hill.

Course Title: Petroleum Transmission

Course Code: CHE712

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Transport of petroleum to distant delivery points: present unique challenges. This course is to equip graduate students with sufficient technical details to enable them to address the multidisciplinary issues relating to petroleum transmission.

Course Contents:

Petroleum Properties; Quality; Transportation; Energy Pricing. Raw petroleum transmission: Calculating Flow Pressure Gradients; Pipelines; Temperature Profile Pipelines Operations, Offshore, Sea, Tanker Transmission Practices and Aspects; Petroleum & Gas Flow concerns.

Reference Books:

1. E. Shashi Menon, Gas Pipeline Hydraulics, (2005), CRC Press Taylor & Francis.
2. J. M. Prausnitz., J. P. O. Connell. The Properties of Gases and Liquids, B.E. Poling, (2001), McGraw Hill, New York.
3. Pipeline Design and Construction: A Practical Approach, ASME Press, American Society of Mechanical Engineers, (2000), New York.

Course Title: Natural Gas Transmission

Course Code: CHE713

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Transport of natural gas by pipelines to distant delivery points: presents unique challenges of flow through long conduits. Furthermore, the processing of the gas to meet delivery specifications requires process systems design. This course is to equip graduates students with sufficient technical details to enable them to address above mention issues relating to the natural gas processing and transmission.

Course Contents:

Natural Gas Origin and Composition; Sources; Phase Behavior; Properties; Quality; Transportation; Natural Gas Energy Pricing. Raw Gas Transmission: Multiphase Flow Terminology; Multiphase Regimes; Calculating Multiphase Flow Pressure Gradients; Multiphase Flow in Gas/Condensate Pipelines; Temperature Profile of Multiphase Pipelines; Velocity Criteria for Sizing Multiphase Pipelines; Multiphase Flow Assurance Monitoring; Multiphase Pipelines; Multiphase Flow Assurance Monitoring; Multiphase Pipelines Operations. Sales Gas Transmission: Gas Flow Fundamentals; Predicting Gas Temperature Profile; Compressor Stations and Associated Pipeline; Design Consideration of Sales Gas Pipelines; Pipeline Operations.

Reference Books:

1. E. Shashi Menon, Gas Pipeline Hydraulics, (2005), CRC Press Taylor & Francis.
2. J. M. Prausnitz., J.P.O. Connell. The Properties of Gases and Liquids, B.E. Poling, (2001), McGraw Hill, New York.
3. J. J. Carroll. Natural Gas Hydrates, A Guide for Engineers, (2002), Gulf Professional Publishing, Amsterdam, The Netherlands.
4. Pipeline Design and Construction: A Practical Approach, ASME Press, American Society of Mechanical Engineers, New York, (2000).
5. A. L. Kohl., F.C. Risenfeld. Gas Purification, (1985), Gulf Professional Publishing, Houston, TX.

Course Title: Chemicals Emission and Control

Course Code: CHE720

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive understanding of all air pollution aspects, management and the engineering controls used to reduce emissions from industry and transport.

Course Contents:

Atmospheric Physics, Chemistry and Thermodynamics, formation and removal of atmospheric pollutants, Air pollution phenomena, fates of air pollutants, and impact on human health, methods and procedures for air pollutant measurement, management and control. Air pollution modeling techniques for institutional air quality management framework in compliance to ever increasing legislative and pollution mitigation needs.

Reference Books:

1. William Licht, Air Pollution Control Engineering: Basic Calculations for Particulate Collection, (1988), Camber Southeast, Inc.
2. Wayne T. Davis, Electrostatic Precipitator Handbook, (2000), Camber Southeast, Inc.
3. Nicholas J. Bahr, Air Quality Control Handbook, (1997), Camber Southeast, Inc.

Course Title: Fate and Transport of Chemical in Environment

Course Code: CHE721

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide an integrated coverage of major environmental media, quantitative treatment of fate and transport processes.

Course Contents:

Fundamental principles of mass transport, chemical partitioning, and chemical/biological transformations in surface waters, soil, groundwater, air, controlling physical, chemical, and biological processes, mathematical models for chemical transport and transformations in the environment

Reference Books:

1. Dunnivant, Frank M. Anders, Elliot, A Basic Introduction to Pollutant Fate and Transport, John Wiley & Sons, (2006).
2. John H. Montgomery, Groundwater Chemicals Desk Reference, ((3rd ed.)), (2000), CRC.
3. Harold F. Hemond, Chemical Fate and Transport in Environment, (2000), Academic Press.

Course Title: Industrial Environmental Microbiology

Course Code: CHE722

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The course introduces students to complex concepts in water microbiology, food microbiology, sterility and disinfection, the use of microorganisms in manufacturing processes and in the degradation of contaminates in the environment.

Course Contents:

The vital role of microbes in marine, freshwater and terrestrial ecosystems by exploring the dynamic interactions that take place between microbial communities, the surroundings and higher organisms, microbial diversity and function, sensing and adaptive responses of bacteria, biogeochemical cycling and microbial communities and interactions, , role of microbes in the ecological, biogeochemical and bioremedial processes in different environments, Applications to a range of environmental problems , sustainable resources and commercial applications of environmental biotechnology

Reference Books:

1. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, (2000), Environmental Microbiology, ((1st ed.)), Academic Press.
2. Ralph Mitchell, Ji-Dong Gu, Wiley-Blackwell, (2009), Environmental Microbiology, ((2nd ed.)).
3. Patrick K. Jjemba, (2004), Environmental Microbiology: Principles and Applications, Science Pub Inc.

Course Title: Industrial Environmental Chemistry

Course Code: CHE723

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The main objective of this course is to gain an understanding of the chemical processes that are central to a range of important environmental problems and to utilize this knowledge in making critical evaluations of industrial problems.

Course Contents:

Principles of chemistry, pollutants source, fate, and reactivity of compounds in natural and polluted environments, phase interactions, and biochemistry of aquatic microbial, environmental implications of energy utilization, chemistry of the atmosphere, hydrosphere, and lithosphere. Industrial chemicals and issues related to air pollution, stratospheric ozone depletion, pollution and treatment of water sources, insecticides and herbicides, etc.

Reference Books:

1. Stanley E. Manahan, (2004), Environmental Chemistry, CRC Press.
2. Mohan Singh, (2007), Environmental Chemistry: Fundamentals, Jorge G. Ibanez, Margarita Hernandez-Esparza, Carmen Doria-Serrano, Arturo Fregoso-Infante, Springer.

Course Title: Hazardous and Toxic Chemical Waste Treatment

Course Code: CHE724

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide an introduction to the important topics of environmental ethics. To assess remediation technologies for contaminated soil/groundwater under saturated and unsaturated conditions .To offer necessary equations and design examples to evaluate the effectiveness of different treatment and containment technologies in addressing today's hazardous waste situations. To provide experiences in realistic civil and environmental engineering design and construction practice. To develop teamwork and communication skills required for multi-disciplinary civil and environmental engineering objectives.

Course Contents:

Regulations, Introduction to Contaminant Nature and Remediation Technologies. Site and Subsurface Characterization - Methodology, Planning, Site Characterization, Geographic Information System, Case History Pollution Prevention - Management Strategies, Life Cycle Analysis, Volume Reduction, Toxicity Reduction, Recycling Extraction Technologies (Soil): Supercritical Fluid Extraction, Chemical Dehalogenation Treatment (Liquid and Solids) Toxicology - Pharmacokinetics, Toxic Effects, Dose-Response relationships Process Fundamentals and Contaminant Pathways - Physical-Chemical Properties, Process Selection Procedure, Contaminant Release, Contaminant Transport Extraction Technologies (Liquid): Oil and Grease Extraction Technologies (Liquid): Air Stripping Extraction Technologies (Soil): Soil Vapor Extraction - Principle and Design Extraction Technologies (Soil): Soil Vapor Extraction - Design and Field Application Thermal Methods - Regulations, Combustion, Gases and Vapors, Incinerators, Air Pollution Control, Instrumentation Granular Activated Carbon (Liquid & Off-Gas) Solvent Extraction (Liquid and Solids) Air Sparging System (Groundwater) In Situ Bioremediation (Liquid) and Bioventing (Soil) Composting and Heap Pile Bioremediation Advanced Oxidation Processes (Liquid, Gas & Solids) Photochemical Processes (Liquid and Gas) Quantitative Risk Assessment -Hazard Identification, Exposure Assessment, Risk Assessment, Case Study.

Reference Books:

1. Michael LaGrega, Phillip Buckingham, Jeffrey Evans, Basic Hazardous Waste Management (2001), ((2nd ed.)) by William C. Blackman.
2. Mickel L., et.al, Hazardous Waste Management, (2000), MacGraw Hill.

Course Title: Bioremediation of Toxic Chemicals

Course Code: CHE725

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The use of genetic engineering to create organisms specifically designed for bioremediation has great potential. The main objective of this course is to give an in-depth knowledge to the student about the use of microorganism metabolism to remove wide range of pollutants.

Course Contents:

Introduction, Genetic systems in soil bacteria for the degradation of polychlorinated biphenyls. Selection of enhanced polychlorinated biphenyl-degrading bacterial strains for bioremediation: consideration of branching pathways, Chlorophenol degradation. Microbial metabolism of polycyclic aromatic hydrocarbons, Microbial ecology of polycyclic aromatic hydrocarbon (PAH) degradation in coastal sediments. Biodegradation of chlorinated homocyclic and heterocyclic compounds in anaerobic environments. Biodegradation of sulfonated aromatics. The biodegradation of morpholine. Microbial metabolism of carbamate and organophosphate pesticides, Biodegradation of low-molecular-weight halogenated organic compounds by aerobic bacteria, Anaerobic utilization of aromatic carboxylates by bacteria, Biodegradation of trichloroethylene in methanotrophic systems and implications for process applications, Properties of lignin-degrading peroxidases and their use in bioremediation, Biological disposal of lignocellulosic wastes and alleviation of their toxic effluents, Biodegradation of toxic chemicals by white rot fungi, Recent advances in bio processing of coal, microbial desulfurization of coal with emphasis on inorganic sulfur.

Reference Books:

1. Anna-Irini Koukkou, Microbial Bioremediation of Non-metals Current Research, (2011), Caister Academic Press.
2. G.R. Chaudhry, L. Ljundahl, Biological Degradation and Bioremediation of Toxic Chemicals, (1995), Kluwer Academic Publishers.
3. Ronald L. Crawford, Don L. Crawford, Bioremediation: Principles and Applications, (1997), Cambridge University Press.

Course Title: Solid Waste Engineering

Course Code: CHE726

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To understand the engineering and scientific principles of municipal solid waste (MSW) management. Gain insight into the collection, transfer, and transport of municipal solid waste. Understand the design and operation of a municipal solid waste landfill. Understand the design and operation of a resource recovery facility. Understand the design and operation of a waste-to-energy facility.

Course Contents:

This course covers advanced engineering and scientific concepts and principles applied to the management of municipal solid waste (MSW) to protect human health and the environment and the conservation of limited resources through resource recovery and recycling of waste material. Topics include regulatory aspects and hierarchy of integrated solid waste management; characterization and properties of MSW; municipal wastewater sludge utilization; hazardous waste found in MSW; collection, transfer, and transport of solid waste; separation, processing, combustion, composting, and recycling of waste material; and the landfill method of solid waste disposal, which encompasses guidelines for design, construction, operation, siting, monitoring, remedial actions, and closure of landfills. Permitting and public participation processes, current issues, and innovative approaches are also addressed

Reference Books:

1. W. A. Worrell., P. A. Vesilind., Solid Waste Engineering, ((2nd ed.)), (2011), Cengage Learning.
2. W. B. Robison, the solid waste handbook, a practical guide, (1986), John Wiley and Son.
3. Jagbir Singh, Solid Waste Management, (2010) International Publishing House Pvt. Ltd.

Course Title: Bio-Reaction Engineering

Course Code: CHE730

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The purpose is this course is to specialize chemical engineers for the designing of reactors with some quite specific characteristics of bio-reactions, which require specialist treatment, e.g. the complex stoichiometric networks of metabolism. Biochemistry, microbiology and chemical engineering are all used to obtain a deeper insight into the complex world of bioreactions.

Course Contents:

The purpose of this course is to calculation, mathematical modelling and designing of enzyme catalyzed reactions, optimal batch and chemostat fermentations based on simple reaction kinetics, metabolic control analysis in a simple reaction network. Heat of production in fermentation process. This subject also covers the principles for the design and scale-up of a bioreactor.

Reference Books:

1. Jens Nielsen., John Villadsen and Gunnar Liden. Bioreaction Engineering Principles, ((2nd ed.)), (2003), MacGraw Hill.
2. K. Schügerl., K.-H. Bellgardt. Bioreaction Engineering: Modeling and Control (2000), ((1st ed.)), CRC Press.

Course Title: Bio-Process Design

Course Code: CHE731

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop the students' knowledge and appreciation of the conceptual and factual bases for bioprocess design and operation and to develop the understanding of biochemistry, in particular the structures, roles and experimental methods associated with biopharmaceuticals and their analysis. It also provides the students with an awareness of the regulatory affairs environment in the Biopharmaceutical industry.

Course Contents:

To carry out a bioprocess on a large scale, it is necessary to investigate and develop three principle areas: to obtain the best biocatalyst (microorganisms, animal cell, plant cell, or enzyme) and medium optimization for a desired process, to create the best possible environment for the catalyst to perform by designing the bioreactor and operating it in the most efficient way and to separate the desired products from the reaction mixture in the most economical way. This course endeavors to answer these questions in a systematic and conceptual way

Reference Books:

1. Michael L.Shuler., Fikret Kargi. Bioprocess Engineering: Basic Concepts, (2nd ed.), (2001).
2. Ghasem D. Najafpour. Biochemical engineering and biotechnology (1st ed.) (2007), Elsevier.
3. Joaquim M. S. Cabral., Manuel Mota., J. Tramper, Multiphase bioreactor design (2001), Taylor & Francis.
4. Elmar Heinzle., Arno P. Biwer., Charles L. Cooney. Development of sustainable bioprocesses: modeling and assessment (2006), Wiley.
5. Donald Lee Wise., Marcel Dekker. Bioprocessing and biotreatment of coaly (1990), INC.

Course Title: Production of Biofuels

Course Code: CHE732

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The main objective of the course is to apply the knowledge in microbiology and process engineering to the biological conversion processes of biomass into biofuels (bioethanol, biogas, biohydrogen and biodiesel). The main focus will be on the potential and possible solutions for the technical implementation of biofuels production from different biomass resources.

Course Contents:

This course covers the conversion of organic matters into biogas, biohydrogen, bioethanol, and biodiesel. The selection of economically feasible process for the production of biofuels. The suitable biomass resources for the production of the different biofuels by regarding the biomass composition characteristics. Calculation of theoretical potential for the different biofuels from the different biomass resources. Estimation of practical biofuels yield from different biomass resources and explain the difference to the theoretical yield and the necessary mechanisms for increasing the yields.

Reference Books:

1. Caye Drapcho., John Nghiem., Terry Walker. Biofuels Engineering Process Technology, (2008), ((1st ed.)).
2. Alain Verts, Nasib Qureshi, Hideaki Yukawa, Hans P. Blaschek. Biomass to Biofuels: Strategies for Global Industries, (2010), ((1st ed.)).

Course Title: Metabolic and Cell Engineering

Course Code: CHE733

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Metabolic and Cell engineering addresses issues related to understanding and manipulating cell structure-function relationships. This course is intended to be a bridge between cell biologists and engineers, to understand quantitatively cell biological aspects. Metabolic and Cell engineering is intrinsically connected to the new field of tissue engineering. Starting with an introduction to engineering principles and modeling at the cellular level of particular interest are cytomechanics, receptor/ligand binding, genetic engineering, enzyme kinetics, and metabolic pathway engineering.

Course Contents:

Basic cell biology and processes, Mechanics of cells and sub cellular elements (flow, hydrostatic pressure, tension, torsion, flexure, and combined loads), Receptors, ligands, and interactions, Gene transfer techniques and genetic engineering, Enzyme kinetics, Metabolic pathway engineering.

Reference Books:

1. Mohamed Al-Rubeaj. Cell Engineering, (1st ed.), (1999), Springer.
2. Mohamed Al-Rubeai. Cell Line Development (Cell Engineering), vol 6, (2009), Springer.
3. Michael R. King. Principles of Cellular Engineering: Understanding the Biomolecular Interface, (2005), Academic press.
4. Walter X. Balcavage., Michael B. Worrell., Thomas D. Hurley., James P. Hughes., Taihung Duong., Michael W. King., David A. Prentice., Gabi Nindl Waite., Lee R. Waite. Applied Cell and Molecular Biology for Engineers (2007), McGraw-Hill Professional.

Course Title: Manufacturing Practices for Bioprocesses

Course Code: CHE734

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course covers in-depth coverage of the development and implementation of manufacturing practices (GMPs) in the biotech industry. Topics include building and facilities, equipment design, utilities, in-process controls, records and adequate process validation.

Course Contents:

The purpose of this course is to train Chemical engineers for the quality assurance in bioprocess industries. It includes equipment, production and process control, microbiological, chemical and physical Safeties involved in bioprocess. The subject covers all the considerations to ensure the quality of the product.

Reference Books:

1. Michael L., Kargi., Fikret Shuler. Bioprocess Engineering: Basic Concepts ((2nd ed.)), (2001).

Course Title: Polymer Rheology

Course Code: CHE740

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides an overview of polymer rheology with emphasis on application to polymer processing. This course will cover the general methods for rheological characterization of liquid and solid polymers. The knowledge gained about rheological principles is then applied, together with standard conservation laws, to the analysis and derivation of basic models for several key polymer fabrication processes.

Course Contents:

Linear Elastic Solids, Basic forces: expansion/contraction, extension and shear, Stress tensors and deformations, Interrelationships between elastic moduli, Poisson's ratio, Thermodynamics of elasticity, Linear Viscous Fluids, Newtonian flow and simple shear, Measurement of viscosity: Capillary, Couette, cone/plate flow, Viscosity of suspensions and dilute polymer solutions, Viscosity of concentrated and undiluted polymers, Linear Viscoelasticity, Nature of the viscoelastic response, Creep, creep/recovery, and stress relaxation, Sinusoidal deformations and isochronal experiments, Tg and time-temperature superposition, Non-linear Effects

Reference Books:

1. Goodwin, James William, and Roy W. Hughes. Royal Society of Chemistry, (2008).
2. Hiemenz, Paul C., and Timothy P. Lodge. Polymer Chemistry. CRC press, (2007).
3. Young, Robert J., and Peter A. Lovell. Introduction to Polymers. CRC press, (2011).
4. Larson, Ronald G. The Structure and Rheology of Complex Fluids. Vol. 150. New York: Oxford university press, (1999).
5. Rudolph, Natalie, and Tim A. Osswald. Polymer Rheology: Fundamentals and Applications. Carl Hanser Verlag GmbH Co KG, (2014).

Course Title: Principles of Polymer Conversion Operations

Course Code: CHE741

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of this course is to develop a better understanding in graduate students regrading all aspects of the current polymer compounding processes, plastics injection molding and product engineering. Additionally, this course would include deeper knowledge of polymers and polymer related processes. On successful completion of the course, students will able to understand Principles of polymer compounding & processing, its effects on morphological structure and properties of manufactured plastic products. Material and process selection, product design for manufacturing, plastics conversion techniques, especially injection molding and in-mold plastics bonding

Course Contents:

Fundamentals of polymer processing, Introduction to polymer engineering, Compounding and processing of polymers, Structure and characterization of polymers, Processing of thermosets, Plastics and ecology, Business and management aspects of polymer processing., Essentials management and quality control (QC)techniques that are useful in polymer processing unit. Practical training on Injection Molding Machine will also be the part of course.

Reference Books:

1. D.W. Van Krevelan, Properties of Polymers, Correlation with Chemical Structure, Elsevier Amsterdam, (1990).
2. W.B. Billmeyer, Textbook of Polymer Science, (3rd ed.), (1984), Wiley.
3. S.L. Rosen, Fundamental Principles of Polymeric Materials, (1982), Wiley.
4. D.J. Williams, Polymer Science and Engineering, (1971), Prentice-Hall.
5. E.C. Bernhardt, Processing of Thermoplastic Materials, (1959), Reinhold.
6. Cheremisinoff, Nicholas P. Advanced Polymer Processing Operations. William Andrew, (1998).
7. Asua, José M., ed. Polymeric Dispersions: Principles and Applications. Vol. 335. Springer Science & Business Media, (2012).

Course Title: Polymer Membranes

Course Code: CHE742

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course will provides a comprehensive overview on the development of polymeric membranes having advanced functions in the various membrane separation processes for liquid and gaseous mixtures (gas separation, reverse osmosis, pervaporation, nanofiltration, ultrafiltration, microfiltration) and in other important applications of membranes such as biomaterials, catalysis (including fuel cell systems).

Course Contents:

The course will describe in detail membrane separation technology and wide range of applications e.g classification of membranes & process, Fabrication techniques, Transport Processes in membranes & their performance characterization, Thermodynamic considerations, Phase equilibria in polymer ternary systems, Morphology of membranes., Fouling of membrane, Gas separation process through membrane technology, Characteristic properties of membranes, Ion-Exchange Membranes, Heterogenous and homogenous membranes, Fluorocarbon membranes, Methods of testing

Reference Books:

1. S. Ramakrishna, Z. Ma., T. Matsuura, Polymer Membranes in Biotechnology: Preparation, Functionalization and Application, (2010), World Scientific Publishing co.
2. Xu, Zhi-Kang, Huang, Xiao-Jun, Wan, Ling-Shu, Surface Engineering of Polymer Membranes, (2009), Zhejiang University Press.
3. S. M. Javaid Zaidi, Takeshi Matsuura, Polymer Membranes for Fuel Cells, Springer Verlog, (2008).
4. B. D. Freeman, I. Pinnau, Polymer Membranes for Gas and Vapor Separation: Chemistry and Materials Science, (1999), ACS, Symposium Series.

Course Title: Sol-Gel Processing

Course Code: CHE743

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Sol-Gel Processing is designed to Provide in-depth Knowledge of technique widely used in the fields of materials science and engineering and the methods used primarily for the fabrication of materials (typically a metal oxide) starting from a chemical solution (or sol) that acts as the precursor for an integrated network (or gel) of either discrete particles or network polymers.

Course Contents:

Introduction to Sol-Gel Processing, Chemistry of precursor's solutions, Sol-Gel process of silica Sol-gel process of complex oxides, Sol-gel process of hybrid materials, Sol-gel Process of Mesoporous Materials, Preparation of Stable Solutions, Organic-Inorganic Hybrid Systems, Applications as a Protective coatings, food industry, Thin films and fibres.

Reference Books:

1. Sumio Sakka. HandBook of Sol-gel Science and Technology: Processing Characterization and Applications Volume 1, (2004), Kluwer Academic Publishers.

A. C. Pierre. IntroIntrduction

2. duction to Sol-Gel Processing, (1998), Kluwer Academic Publisher.
3. C. J. Brinker., G. W. Scherer, Sol Gel Science, (1990), Academic Press.

Course Title: Membrane Science & Technology

Course Code: CHE744

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide a comprehensive overview on the development of membranes and membrane based separation technology for liquid and gaseous mixtures

Course Contents:

Introduction and history of Membranes and Membrane Separation Processes; Membrane Materials and their properties (organic and inorganics); Phase inversion in polymers; Phase inversion membranes (NIPS, TIPS, VIPS, etc.); Techniques for the fabrication of membranes; Characterization of Membranes; Transport Processes through membranes; Application of polymer membranes in different processes: gas separation, reverse osmosis, pervaporation, nanofiltration, ultrafiltration, microfiltration, pervaporation, fuel cell technologies, membrane bioreactors, membrane distillation, membrane dialysis; Challenges with application of membrane technology; Membrane Modules & Process Design.

Reference Books:

1. R. W. Baker, Membrane Technology and Applications, (2012), Third Edition, John Wiley and Sons Ltd.
2. Marcel Mulder, Basic Principles of Membrane Technology, (2nd ed.) Kluwer Academic Publications, (1996).
3. S. Ramakrishna, Z. Ma., T. Matsuura, Polymer Membranes in Biotechnology: Preparation, Functionalization and Application, (2010), World Scientific Publishing co.
4. Xu, Zhi-Kang, Huang, Xiao-Jun, Wan, Ling-Shu, Surface Engineering of Polymer Membranes, (2009), Zhejiang University Press.
5. B. D. Freeman, I. Pinnau, Polymer Membranes for Gas and Vapor Separation: Chemistry and Materials Science, (1999), ACS, Symposium Series.

Course Title: Textile Quality Assurance

Course Code: CHE750

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Principles of quality control and assurance are inculcated using case studies. Emphasis is on global quality standards being implemented in the textiles & apparel industry. Analysis of products, comparison with standards and reporting of results are the key areas to improve a product or the process of manufacturing the product. Students will be able to understand the basics of producing a high quality product.

Course Contents:

Quality Assurance: Concepts (various definitions and approaches) used for quality, significance and applications of quality control. Difference in quality control and quality assurance, and their uses. Statistical techniques SPC, FMEA, and their influence on improving the quality of textile processes and products. Sampling and measuring methods used for determining fabric and yarn properties. Spinning Process Control: Raw material control, and its effects on process, on- line and off- line process controls, yarn clearing control. Weaving Process Control: Raw material control, on- line and off- line weaving process control, fault control. Making- up Process and Its Relation with Fabric Properties: Characteristics and faults of fabrics, AEIH Recommendations, Care labeling: types and use.

Reference Books:

1. Sara J. Kadolph, Quality Assurance for Textiles and Apparel, ((2nd ed.)), (2007) Textile Testing Solutions, SDL Atlas, (2005).

Course Title: Mechanics of Textiles

Course Code: CHE751

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

In this course, the students will study about the mechanics of engineering materials, including textile yarns and fabrics, plasticity of textile fibres, compression of textile materials, drape and hand of woven and knitted fabrics.

Course Contents:

Hierarchical mechanical dependency relationships in textiles are discussed. Included are the role of fiber and yarn twist, yarn crimp, finishes, and coatings to mechanical response of textiles. Dynamic and static response to various types of loading are investigated. Tearing, abrasion, and wear properties as a function of textile form are presented.

Reference Books:

1. Ferdinand Pierre Beer, Mechanics of Materials, (2008).
2. Jinlian Hu, Structure and mechanics of woven fabrics, (2004), Woodhead Publishing in Textiles.
3. A. Bogdanovich., C. Pastore. Mechanics of Textile and Laminated Composites, (1996).

Course Title: Advanced Yarn Engineering

Course Code: CHE752

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

In this course the students will study carding, drawing, combing, roving, ring spinning, woolen/worsted spinning systems, auto winding and yarn packing In-depth study of ring spinning frame will be discussed in this course. Modern concepts related to drafting, twisting, and package formation on roving frame and ring spinning frame will be focused. Different effects of conditioning and environmental conditions will also be discussed in this course.

Course Contents:

Yarn Manufacturing: Production processes for continuous filament, staple, novelty, bulk and stretched yarns. Explanations and discussions of stress- strain properties of nylon, polyester, viscose, aramid, spandex, sara, glass and metallic fibers. Fibre Blending: Blends, blending system, processing of blend and synthetic staple fibers into yarn. Blending of cotton with man- made fibers. PET Production Equipment: Equipment used for the production of polyester fibers, starting from the PET chips- study of equipment and material, and their effects on process. Manufactured Fibers (Synthetic Fibers): Manufacturing process (brief), properties and application (uses) of Viscose Rayon, Lyocell, Polyamide, Acrylic.

Reference Books:

1. Brearley., Iredale. The Woolen & Worsted Industry, (2003).
2. Gilbert R.Merrill, Manual of Cotton Spinning, (1999).
3. Eric Oxtoby, Spun Yarn Technology, (1987).

Course Title: Fiber Forming Polymers

Course Code: CHE753

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Upon successful completion of the course students are expected to comprehend the theory of synthetic macromolecule along with their synthesis and characterization. Apply the procedures and control of fiber production, analyze structures, processes and techniques of polymer optimization and quality assurance.

Course Contents:

Introduction and basic concepts, polymer processing methods, synthetic textile fibers, Classification of polymers, Basic polymerization reactions, Natural polymers (cellulose and keratin), Synthetic polymers (polyamides, polyacrylonitriles, polyesters), fiber production, Synthesis, structure, morphology, stereochemistry, properties, spinning and dyeing of textile polymers, Textile polymer materials, modern polymer fibers, production methods, general characteristics, dyeing applications of textile polymers, properties, uses. Multiblock copolymers, synthesis, yarn production, molecular characterization, morphology, properties. Molecular weights determination by size exclusion chromatography (SEC), traditional natural polymer fibers and modern textile synthetic polymers, viscosity measurements in solution, membrane osmometry (MO), light scattering. UV–Visible and Infrared spectroscopies for textile fiber recognition, Colorimetric determination of polymer concentration, influence of concentration on the quality of textile fibers, X-ray diffraction (XRD), polymer crystallization, Differential Scanning Calorimetry (DSC), Electron microscopy (SEM, TEM) for studying of textile fibers morphology, Melting, glass transition temperature, crystallinity and mechanical properties of fibers, designing of the products with improved features, develop techniques of filling, plasticizing and coating, Fillers, plasticizers. Polymeric coatings, identification of textile fibers by ASTM

Reference Books:

1. J. M. G. Cowie, Polymers: Chemistry and Physics of Modern Materials, ((2nd ed.)), Blackie Academic and Professional, (1994).
2. John W. S. Hearle., W. E. Morton. Physical Properties of Textile Fibres, (2008).
3. R. A. Charvat, Coloring of Plastics: Fundamentals, John Wiley and Sons, (2003).

Course Title: Scientific Communication for Engineering Research

Course Code: CHE760

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The primary objective of this course is to equip students with essential skills for scientific research writing and effective presentation. By the end of the course, students will develop a structured approach to writing synopses, theses, and research articles. Learn to communicate complex ideas clearly and concisely through written and verbal means. Gain proficiency in preparing and delivering impactful scientific presentations. Understand the conventions of scholarly writing and publishing in engineering disciplines. Understand and apply academic writing conventions, including proper citation and referencing. Master referencing techniques and ethical practices, including avoiding plagiarism in engineering research.

Course Contents:

Introduction to Engineering Research Writing: Importance of precision, clarity, and objectivity in technical writing. Common challenges in engineering research documentation. Role of communication in the research process. Fundamentals of Academic Writing for Engineers: Developing clear and concise technical sentences. Incorporating domain-specific terminology and addressing common errors in engineering writing. Communicating technical concepts effectively to diverse audiences. Drafting a Synopsis for Engineering Projects: The purpose and structure of a technical synopsis are as follows: outlining objectives, problem statements, methodology, and anticipated results. Crafting a synopsis for written and oral presentations. Writing Engineering Theses: Key sections: abstract, introduction, literature review, experimental setup, results, discussions, and conclusions. Presentation of technical diagrams, data, and references following engineering standards. Strategies for presenting thesis findings during oral defenses and reviews. Composing Research Articles in Engineering: Guidelines for drafting abstracts, problem definitions, and results discussions. Preparing technical figures, tables, and charts for journal publications. Aligning with editorial requirements of high-impact engineering journals. Preparing research highlights and graphical abstracts for effective communication. Citations and Referencing in Engineering Research: Overview of referencing styles (IEEE, APA, etc.) used in engineering research. Tools for managing citations and ensuring accuracy. Ethical communication of references and ideas. Peer Review and Manuscript Improvement: Insights into the peer review process in engineering journals. Techniques for self-editing and enhancing technical drafts for publication. Communicating with reviewers and responding to feedback constructively. Technical Communication and Presentation Skills: Preparing and delivering effective technical presentations. Designing impactful slides with a focus on clarity and visual appeal. Communicating complex technical ideas to technical and non-technical audiences. Enhancing verbal and non-verbal communication for research presentations.

Reference Books:

1. Finkelstein, L., Aune, J. E., & Potter, L. A. (2022). *Technical writing for engineers & scientists* (4th ed.). McGraw-Hill.
2. Martin, T. P. (2022). *Technical writing for engineers who don't like to write: A straightforward guide written by an engineer for engineers*. Kitzi Press.
3. Glasman-Deal, H. (2020). *Science research writing for non-native speakers of English* (2nd ed.). World Scientific.
4. Belcher, W. L. (2019). *Writing your journal article in twelve weeks: A guide to academic publishing success* (2nd ed.). University of Chicago Press.
5. Alley, M. (2018). *The craft of scientific writing* (4th ed.). Springer.
6. Day, R. A., & Gastel, B. (2016). *How to write and publish a scientific paper* (8th ed.). Cambridge University Press.
7. Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). University of Michigan Press.

Course Title: Clean Coal Technologies

Course Code: ENE612

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides a comprehensive knowledge of clean coal technologies and initiates the development of a low emission and high efficiency power plant by using clean coal technologies.

Course Contents:

Coal; life cycle, characterization, classification system and rank/ grade. Coal washing. Clean coal technologies; definition, objectives, technology options (pre-combustion, combustion and post combustion), coal to liquid fuel and coal to gaseous fuel. Coal mining; techniques and their environmental effects. Chemical looping combustion. Carbon dioxide capture and sequestration technologies. Advanced thermodynamics and energy efficiency analysis. Case studies; exergy analysis of coal fired power plants (combustion and/or gasification) and their environmental effects. Environmental impact of clean coal technologies.

Reference Books:

1. Moghtaderi, B. and Wall, T. Advanced Clean Coal Technologies. Royal Society of Chemistry, (2014).
2. Speight, J.G. Coal-Fired Power Generation Handbook. (1st ed.) Wiley-Scrivener, (2013).
3. Reddy, P.J. Clean Coal Technologies for Power Generation. CRC Press, (2013).
4. Miller, B.G. Clean Coal Engineering Technology. (1st ed.) Oxford: Butterworth-Heinemann, (2010).
5. Bell, D.A. and B.F. Towler. Coal Gasification and its Applications. (1st ed.) William Andrew, (2010).

Course Title: Solid Waste Management

Course Code: ENE623

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide fundamental understanding of technical issues and the management of solid waste management including the transportation, reuse, recycling and treatment.

Course Contents:

Solid waste management; introduction and theory, sources, quantities and composition. Solid waste generation and composition. Transportation of solid wastes. Reuse and recycling technologies; composting. Solid waste treatment; biological treatment, thermal treatment. Landfill systems; site design and management, risk assessment of landfills, pollution from landfills, waste decomposition in landfills, landfill gas collection and recovery. Leachate and their collection system design and treatment processes. Municipal solid waste strategies. Solid waste issues in developing and emerging countries. A related case study.

Reference Books:

1. Wang, L. K., & Pereira, N. C. (Eds.). Solid waste processing and resource recovery (Vol. 2). Springer Science & Business Media, (2015).
2. White, P., Dranke, M., and Hindle, P. Integrated solid waste management: a lifecycle inventory. Springer Science & Business Media, (2012).
3. Daniel, D.E. (Ed.). Geotechnical practice for waste disposal. Springer Science & Business Media, (2012).
4. Vesilind P.A., Worrell W.A. and Reinhart D.R. Solid Waste Engineering. Australia: CL-Engineering, (2001).
5. Tchobanoglous G., Theisen H. and Vigil S. Integrated Solid Waste Management: Engineering Principles and Management Issues. New York: McGraw-Hill, (1993).

Course Title: Environmental Pollution Control

Course Code: ENE624

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To identify the major sources of air and noise pollution and their impacts on environment and to create an understanding of climate change on natural ecosystem

Course Contents:

Introduction, Meteorology, climatology, Sources, Classification and Effects of air pollutants; Sampling and Monitoring Techniques, Indoor & Outdoor (Industrial and Vehicular Emissions) air quality assessment; Plume Dispersion Model, Air pollution control techniques including catalytic methods, Chemistry of climate change and its impacts on to the ecosystem, EM radiations and their impacts onto the environment, National and global sources and impacts of climate change on Economy. Air and noise pollution laws and regulations, Noise Pollution-sources and types. The decibel scale, effects of noise; Physiological effects (acute and chronic), psychological effects. Noise control programs in industries; measurement of noise levels, noise control criteria. Interference with communication, hearing loss criteria, permissible exposure limits. Equipment used for noise measurement; different types of meters and analyzers. Approaches for noise control and noise control in industrial establishments.

Reference Books:

1. Schnelle, K. B. Jr., Dunn, R. F. and Ternes, M. E. Air Pollution Control Technology Handbook, (2nd ed.) CRC Press, (2017).
2. Tripathy, D.P. Noise Pollution. APH Publishing Corporation, (2011).
3. Cooper, C.D. and Alley, F.C. Air Pollution Control: A Design Approach. (4th ed.) Waveland Pr Inc., (2010).
4. Mahajan S.P. Air Pollution Control. The Energy and Resources Institute (TERI), (2009).
5. Singal, S.P. Noise Pollution and Control. (1st ed.) Narosa Pub House, (2000).

Course Title: Advanced Energy Engineering

Course Code: ENE714

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide an understanding of energy engineering including its principles, associated environmental, health and safety issues and the structure and management of energy sectors in Pakistan.

Course Contents:

Introduction to energy engineering; energy production, processing, utilization, conservation and the associated environmental, health and safety issues. Energy resources in Pakistan. Energy available from renewable sources. Structure and management of energy sectors in Pakistan; electricity sector and natural gas sector. Principles of energy engineering. Thermodynamics; first law & its application, second law & its application, Irreversibility & energy and basic power generation cycles. Fluid Mechanics; stress-strain relations & viscosity, mass & momentum balance and flow through pipe. Heat Transfer; conduction, radiation and convective heat transfer. Energy supply systems. Energy storage. Trends and impacts of energy use in transport, buildings, appliances and manufacturing systems. Smarter heating and efficient electricity usage in Pakistan. Future energy plans for Pakistan.

Reference Books:

1. Kopanos, G. M., Pei, L. and Georgiadis, M. C. Advances in Energy Systems Engineering. Springer International Publishing, (2017).
2. Sørensen, B.E. Renewable energy: physics, engineering, environmental impacts, economy & planning. (4th ed.) Elsevier Academic Press, (2011).
3. Kalogirou, S.A. Solar Energy Engineering: Processes and Systems. (1st ed.) British Library, (2009).
4. Viswanathan, B. and Scibioh, M.A. Fuel Cells: Principles and Applications. Taylor & Francis Group, (2007).
5. Boyle, G., Everett, B. and Ramage, J. Energy Systems and Sustainability. OUP and Open University, (2004).
6. Scheer, H. A Solar Manifesto. James & James, (2004).

Course Title: Waste to Energy

Course Code: ENE715

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to develop the understanding of waste to energy processes and the skills required for the indigenous design of processes. It also explores the environmental and social benefits of waste to energy processes.

Course Contents:

Introduction to "Waste to Energy". Types of wastes, properties & analysis; agro residues, industrial waste and municipal waste. Waste to energy processes; biochemical processes, thermal processes, chemical processes, thermochemical processes, their design and exergy analysis. Biochemical processes; aerobic digestion and anaerobic digestion. Thermochemical processes; gasification, pyrolysis and liquefaction. Waste incubators. Briquetting; utilization and advantages of briquetting. Waste to energy systems for district heating. Environmental & social benefits of waste to energy conversion.

Reference Books:

1. Reddy, P.J. Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies. CRC Press, (2016).
2. Castaldi, M and Klinghoffer, N. Waste to Energy Conversion Technology. Woodhead Publishing, (2013).
3. Rogoff, M.J. and Screve, F. Waste-to-Energy: Technologies and Project Implementation. (2nd ed.) William Andrew, (2011).
4. Hall, D.O. and Overeed, R.P. Biomass – Regenerable Energy. New York: John Willy and Sons Ltd., (1987).
5. EL-Halwagi, M.M. Biogas Technology- Transfer and Diffusion. New York: Elsevier Applied science Publisher, (1984).

Course Title: Energy and Environmental Policies

Course Code: ENE731

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide an understanding of the mounting concerns regarding energy use and its impact upon the environment. The course also emphasizes the life cycle assessment, environmental impact assessment and energy markets.

Course Contents:

Environmental laws and regulations. Life cycle assessment. Environmental impact assessment. Introduction to environmental economics. Economic policies for environmental regulation. Introduction to energy codes and policies; energy conservation act, solar policy, hydro policy, biomass policy. Global and local energy demand/supply; the oil market, the gas market, the coal market. Climate change and economic growth. The Kyoto protocol. The Paris agreement. Energy policies and market structures: how energy markets are affected from policies and government regulation. Relations between key environmental and energy policy related factors.

Reference Books:

1. Rosenbaum, W.A. Environmental Politics and Policy.(8th ed.) Washington D.C: CQ Press, (2015).
2. Percival, R.V., Schroeder, C.H., Miller, A.S. and Leape, J.P. Environmental regulation: Law, science and policy. Wolters Kluwer Law & Business, (2013).
3. Victor, D.G. Global warming gridlock. (3rd ed.) Cambridge: Cambridge university press, (2011).
4. Burke, G., Singh, B.R. and Theodore, L. Handbook of environmental management and technology. (2nd ed.) John Wiley & Sons Inc., (2005).
5. Lenschow, A. Environmental policy integration: Greening sectoral policies in Europe. Routledge, (2002).

Course Title: Special Topics in Energy and Environment

Course Code: ENE732

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop awareness and indulge in specific research activities To develop strong industry-academia linkage

Course Contents:

A series of lectures by renowned researchers in the field and by Industrial experts shall be conducted. It is an attend only course with either Pass or Fail grading status as per attendance rules and regulations of CIIT. There shall be field trips, research projects, presentations and report writing. List of journals, experts and speakers shall be finalized by the graduate research committee. Details of Courses

Course Title: Nano-materials

Course Code: MME611

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide the students with the knowledge and the basic understanding of nano-materials.

Course Contents:

Emergence of nanotechnology. Zero-dimensional nanostructures: nanoparticles. One-dimensional nanostructures: nanowires, nano-rods, thin films. Multi-layer coatings, consolidated nano-materials, special nanomaterial. Nano-composites: production technologies; rapid solidification technology, rapidly solidified alloys and ceramics; their properties and applications, plasma, laser, melt-extraction and electron-beam processing of nanomaterial, mechanical alloying. Synthesis of nano-materials; vapor deposition. buffer-layer assisted deposition of nano-clusters, physical vapor condensation, gas phase condensation. inert gas condensation. Sol-gel method, swelling of polymers, electrolytic synthesis of nano-materials, template-assisted synthesis of nano-materials, combustion synthesis of nano-materials, amorphous alloys and their nano-crystallization. Properties: physical properties; lattice constants. Mechanical properties; scale and properties, scale dependence of material properties. Thermal prope11ies; melting point, thermal transport. Electrical properties; conductivity, surface scattering, change of electronic structure, quantum transport, the effect of the microstructure. Magnetic prope11ies. Optical properties; surface plasmon resonance. quantum size effects. Acoustic properties. Applications; biological applications, catalysis by gold nano-particles, nanomechanics, carbon nano-tubes emitters. Energy applications of nano-materials; photoelectrochemical cells, hydrogen storage, thermo-electrics. Environmental applications of nano-materials, photonic crystals, and plasmon waveguides.

Reference Books:

1. Bhanvase, B.A., V.B. Pawade, S.J. Dhoble, S.H. Sonawane & M. Ashokkumar. Nanomaterials for Green Energy, Elsevier Science,.
2. Hussain, C.M. & A.K. Mishra. Nanotechnology in Environmental Science. Vol. 2, Wiley,.
3. Guo, Z. and.
4. Tan. Fundamentals & Applications ofNanomaterials. Artech House,.
5. Cao, G. Nanostructures & Nanomaterials: Synthesis, Prope11ies & Applications. Imperial College Press,.

Course Title: Fracture, Creep, and Fatigue of Materials

Course Code: MME612

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The course aims to introduce students to the concepts of material fracture, creep and fatigue and their various analysis techniques.

Course Contents:

Basics of fracture mechanism and ifs applications, the concept of elastic-plastic fracture mechanism, dynamic and time-dependent aspects of fracture, fracture mechanics in metals, fracture toughness testing of metals, fatigue crack propagation, fracture toughness testing of composites materials, environmentally assisted cracking in metals and computational fracture mechanics, engineering aspects of fracture and failure analysis, mechanical and metallurgical causes of failure, modes of failure, fractured surfaces characterization, macroscopic and microscopic features or fracture, fatigue, creep and corrosion assisted/induced failures, fractography, selected case histories and failure prevention methods. Phenomena of creep, the physical mechanism of creep, convenient uniaxial constitutive relationships, steady creep ofa beam in bending. Introduction to creep resistance alloys creep damage parameters, the dependence of creep rate on stress, the dependence of creep rate on temperature, the 8 projection, ashby map, diffusional creep, low-temperature transient creep, high-temperature transient creep. steady-state power-law creep, dispersion strengthening. Stress life relationship, S-N diagram, mean stress effects, modifying factors, strain life relationship, material behavior, the relationship between stress and strain, cycle strain hardening and softening, cyclic stress-strain curve determination, stress-plastic strain power-law relation, strain life curve, mean stress effect.

Reference Books:

1. Bathias C. & Pineau A. Fatigue of Materials & Structures: Application to Damage & Design. Volume 2, John Wiley & Sons,.
2. Hertzberg, R. W. Deformation & Fracture Mechanics of Engineering Materials. John Wiley,.
3. Nabarro, F.R.N. & F. de Villiers. Physics of Creep & Creep-Resistant Alloys. Taylor & Francis, I.
4. Bannantine, J.A., Commer, J.J., & Handrock, J.
5. Fundamentals of Metal Fatigue Analysis. Prentice-Hall, Inc.,.

Course Title: Metals and Alloys

Course Code: MME613

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide an understanding of the various types of metals and alloys, to understand the principles behind heat treatment of metal and alloys, to understand the mechanical behavior of metal and alloys, to understand the electrochemical nature of corrosion of metal and alloys, and to understand the properties and behavior of different classes of materials of materials, strength, ductility and densities.

Course Contents:

Carbon steel, alloy steel, stainless steel, copper, nickel and it's alloys, cobalt and it's alloys, white metals, and their alloys, aluminum alloys, magnesium alloys, titanium alloys, aluminum-lithium alloys, aluminum-magnesium alloys, nickel-base super-alloys, nickel-iron-base super-alloys, and cobalt-base super-alloys. Steel: various classification methods. various phases. and reactions in steel: ferrite reaction, bainite reaction, martensite formation. Alloy steels: effects of alloying elements. Stainless steels; ferritic, martensitic, austenitic, and precipitation-hardening. HSLA steels. maraging steels, dual-phase steels, tool steels. Corrosion of stainless steels. Physical and chemical characterization of metals, lubrication, surface finishing. Characterization of cleaning processes of metals and metal alloys; mechanical cleaning, chemical cleaning, cleaning in a vacuum chamber, detection of hydrogen and miscellaneous cleaning. Relation of structural changes and kinetics of transformation to continuous heat-treatment processes. Thermo-mechanical treatments; controlled rolling, hot-cold working, ausforming, isoform, cryoforming. Austenite grain size and its importance in heat treatment. Controlled atmospheres for heat-treatment. Applications of thermodynamics and mass transport theory. Probable defects, causes, and remedies in heat treatment, heat treatment of structural & tool steels, heat treatment of non-ferrous materials. Applications: copper in medicine, biomedical applications of silver, the potential of metals in combating bacterial pathogens, platinum in biomedical applications, metal-based drugs for malaria treatment.

Reference Books:

1. Rai, M., A.P. Ingle & S. Medici. Biomedical Applications of Metals. Springer International Publishing,.
2. Hume-Rothery, W., H.M. Finniston, D.W. Hopkins & W.S. Owen. The Structures of Alloys of Iron: An Elementary Introduction. Elsevier Science, 20 I.
3. Campos, R.P., A.C. Cuevas & R.A.E. Muiioz. Characterization of Metals & Alloys. Springer International Publishing,.
4. Kassner E. Michael. Fundamentals of Creep in Metals & Alloys. Butterworth-Heinemann,.

Course Title: Thin Film Processing and Characterization

Course Code: MME614

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide students with a comprehensive overview of the fundamentals of thin film preparation and characterization. Also, this course aims to develop a thorough understanding of core physics concepts in the thin film deposition process and establish a correlation between processing variables and materials characteristics.

Course Contents:

An overview of the material science of thin films and vacuum science. Physical vapor deposition (PYO); glow discharges and plasmas, sputtering, hybrid and modified PVD processes. Chemical vapor deposition (CVD); reaction types, thermodynamics ofCVD, gas transport growth kinetics and system. Nucleation and growth; film growth modes, capillarity theory of heterogeneous growth nucleation, nucleation rate and its atomistic models, kinetic models of nucleation, cluster coalescence and depletion. Experimental studies of nucleation and growth, structural aspects of epitaxial films, lattice misfit and imperfection in epitaxial films, methods for depositing epitaxial semiconductor films, optical and mechanical methods for measurement of film thickness, structural, chemical and electrical characterization of thin films, two probe and four probe resistivity measurement techniques, electrical conductivity in metal, insulating and semiconducting thin films, metal semiconductor contacts and interfaces. Magnetic properties of thin films, electro-physical characteristics of conducting films, size effects in the structure of thin films, hall effects in thin films, classification of defects in solids and thin films, electrical noise in thin films and thin-film structures, non-linear conduction and non-equilibrium noise in thin films, electro-migration in thin films. Measurement of film thickness and optical constants, results of optical measurement on films, practical applications of thin films in optics.

Reference Books:

1. Seshan K. Handbook of Thin Film Deposition Processes & Techniques. Elsevier Science,.
2. Zhigal'skii, G.P. & B.K. Jones. The Physical Properties of Thin Metal Films. Taylor & Francis,.
3. Smith, D.
4. Thin Film Deposition, Principles, & Practice. McGraw-Hill,.
5. Heavens, O.S. Optical Properties of Thin Solid Films. Dover Publications,.

Course Title: Advanced Ceramics and Composites

Course Code: MME615

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides a comprehensive knowledge of advanced ceramics and composites and aims to present the latest development, processing. characterization and application of ceramics and modern composite materials.

Course Contents:

Ceramic materials; introduction, properties, classification. behaviors of ceramics as dielectrics, semiconductors, ferroelectrics, toughening, processing and other applications. Composite materials; introduction, classification, reinforcement phase, matrices and layered composites. Carbide and nitride ceramics; thermal treatment, characterization, fabrication, processing and application. Characterization of ceramic and composite materials. Role of interfaces; mechanical, physical and chemical aspects. Development, processing, characterization and application of bioceramics, biocomposites, monolithic nanoceramics, alumina-based nanocomposites, tungsten carbide-based nanocomposites, zirconia based nanocomposites, metal matrix composites, polymer matrix composites, ceramic-matrix composites and carbon-carbon composites. Developments in engineering ceramics; diamond-like-boron-carbon materials and carbon pearls. Role of ceramics in biomedical applications.

Reference Books:

1. Ohji T. & Singh M. Engineered Ceramics: Current Status & Future Prospects. Wiley,.
2. Bansal N.P., Singh J.P., Ko S., Castro R.H., Pickrell G., Manjooran N.J., Nair M. & Singh G. Processing & Properties of Advanced Ceramics & Composites V. Wiley,.
3. Yang N. The Preparation ofNano Composites & Their Applications in Solar Energy Conversion. Springer, 206. Singh D., Zhu D. & Zhou Y. Design, Development, & Applications of Engineering Ceramics & Composites. Wiley, 20 I.

Course Title: Advanced Materials Science

Course Code: MME616

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to present the foundational knowledge and latest trends and development in materials science.

Course Contents:

Classification of materials; metals, alloys, ceramics, polymers and composites. Properties of materials; mechanical, electrical, thermal, magnetic and optical. Relationship of properties to the materials microstructure including atomic bonding. atomic arrangement, crystal structure, co-existing phases, interfaces, defects and impurities. Phase diagrams; interpretation of diagrams, microstructure development in binary and isomorphs systems, binary eutectic phase diagram and iron-iron carbide phase diagram. Driving force for structural change, kinetics of structural change and nucleation. Polymer; structure and mechanical behavior. Structure and its effect on properties of advanced materials; semiconductors, biomaterials, smart materials and nanoenginecred materials. \.1etals. ceramics and polymers: structures, types, deformation & strengthening, corrosion & degradation. synthesis, fabrication. processing and applications. Composites. Crystal imperfections; point defects. line defects, planar defects and volume defects. Economic, environmental and social issues in materials science. Emerging technologies in materials science and engineering; nanocoatings in aerospace industry and nanotechnology for water & wastewater treatment.

Reference Books:

1. Tatsuki Ohji T., Josef Matyas J., Colorado H. & Kanakala R. Advances in Materials Science for Environmental & Energy Technologies VI. Wiley,.
2. Callister W.D. & Rethwisch D.G. Fundamentals of Materials Science & Engineering: An Integrated Approach, 5th ed. Wiley,.
3. Mittemeijer E.J. Fundamentals of Materials Science. Springer.

Course Title: Superalloys and High Performance Materials

Course Code: MME617

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to provide the understanding of superalloys and high performance materials in order to produce critical components used in the most challenging applications.

Course Contents:

Fundamentals of superalloys. Basic metallurgy of superalloys. characteristics, facts and applications. High-temperature strength of metals. Melting and conversion of superalloys; solidification, electric arc furnace (EAF)/argon oxygen decarburization (AOO), vacuum induction melting (VIM), consumable remelt, vacuum arc remelting, electroslag remelting. triple-melted products and ingot conversion and mill products. Powder metallurgy processing; powder superalloys, powder production techniques, powder consolidation techniques. powder-based disk components and other powder-based superalloy components. The concept of high performance materials. Chemical. thermal and mechanical response of high performance materials. Aluminum alloys, titanium alloys and ceramics & glasses; production, behavior and application. Application of high performance materials in aerospace industry, car industry and defense system. Future prospects of superalloys in Pakistan.

Reference Books:

1. Han Y. High Performance Structural Materials. Springer. Porter D.A., Easterling K.E. & Sherif M. Phase transformations in Metals & Alloys. Pub. Chapman & Hall.
2. Youssef H.A. Machining of Stainless Steels & Super Alloys: Traditional & Nontraditional Techniques.
3. Wiley, Gibson , Rosen D. & Stucker B. Additive Manufacturing Technologies. Springer,.
4. Nieh T. G., Wadsworth J. & Sherby D. Superplasticity in Metals & Ceramics. Cambridge University Press,

Course Title: Product Design and Development

Course Code: MME618

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The course aims to provide knowledge to design and develop new materials for passivation, high strength, toughness and biomedical applications.

Course Contents:

The concept of materials design. Crystallography, kinetics and morphologies of materials and alloy transformations. Materials design for passivation. Materials design for strength, toughness and creep & fatigue resistance. Materials design for high-temperature applications in reactive environment. Design requirements of aerospace structured materials; introduction, properties that effect structural efficiency ab initio, properties effecting cost of ownership and cost effecting design. Materials development with case studies; design & microstructure control of stainless steels, design for hardenability & tempering resistance of ultra-high strength steels, inorganic materials, organic. biomaterials & biomimetic materials and nanomaterials. Nanoelectronics in materials development; artificial skin and muscle, electronic textile, flexible gas sensors and plastic solar panels.

Reference Books:

1. Askeland D.R. & Wright W.J. Science & Engineering of Materials. Cengage Learning,.
2. Ashby M.F. & Johnson K. Materials & Design: The A1t & Science of Material Selection in Product Design. Butterworth-Heinemann,.
3. Gessinger G.H. Materials & Innovative Product Development: Using Common Sense. Elsevier,.
4. Crowe D. & Feinberg A. Design for Reliability. CRC Press,.

Course Title: Materials for Sensors and Electronics

Course Code: MME619

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide students with the knowledge of the properties and applicability of specific materials in the domain of electronics and sensors.

Course Contents:

Emerging green materials and technologies for electronics, biocompatible circuits for human-machine interfacing, biocompatible devices, sustainable processes for green electronics, biocompatible materials for transient electronics, paper electronics, sheet type sensors and actuators, materials and novel patterning methods for flexible electronics. Ceramic insulators, highly conductive ceramics, ceramic capacitor materials, piezoelectric and electro-optic ceramics, ferrite ceramics, ceramic sensors, electro-ceramic thin films for microelectronics and Microsystems, ceramic thick-films process and materials, multilayer ceramic technology. Overview of materials for electronic packing, fluxless soldering for microelectronics applications, effect of microstructures on fracture of metal/ceramic interfaces, future ofadvanced composite electronic packing, low thermal expansion composite materials for electronic packing, silicone-based polymer in electronic packing, dielectric films for high temperature-high voltage power electronics. electrically conducting polymers and organic materials, diamond in electronic packages, measurement and properties of materials in electronic packing.

Reference Books:

1. Garcia-Breijo, E., B.G.
2. Perez & P. Cosseddu. Organic Sensors: Materials & Applications. Institution of Engineering & Technology,.
3. Wong, W.S. & A. Salleo. Flexible Electronics: :vlaterials & Applications. Springer US.
4. Buchana, C.R. Ceramic Materials for Electronics. CRC Press, 3" Ed.,.
5. Chung, D.D. Materials for Electronic Packaging. Elsevier Science,.

Course Title: Materials for Solar Energy

Course Code: MME621

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to provide comprehensive knowledge of materials employed to produce solar energy.

Course Contents:

Introduction and challenges of solar energy. Fundamentals of solar cells; energy circulation of photons and electrons, properties of semiconductors, electron & hole energy bands, p-n junctions and photovoltaic effect. Principles of solar cell operation; electrical characteristics, optical properties and typical solar cell structures. Scope of solar energy in Pakistan; solar potential, solar belt and critical challenges in implementation of solar technology. Solar spectrum. Materials issues in solar cells. crystalline silicone solar cell; manufacture and properties of crystalline silicon, high-efficiency silicon solar cell concepts and thin silicon solar cells. Inorganic solar cells, organic solar cells and perovskite solar cells; principle, materials and devices. Emerging solar cell technology; next generation solar cells, multi-junction, quantum size effect, quantum dot and space solar power system.

Reference Books:

1. Reinders A., Verlinden P. & Freundlic A. Photovoltaic Solar Energy: From Fundamentals to Applications. Wiley,.
2. Yang N. The Preparation of Nano Composites & Their Applications in Solar Energy Conversion. Springer, 20 I.
3. Tiwari G.N., Tiwari A. & Shyam. Handbook of Solar Energy: Theory, Analysis & Applications. Springer,.
4. Granqvist C.G. Materials Science for Solar Energy Conversion Systems. Elsevier Science,.

Course Title: Materials for Energy and Environment

Course Code: MME622

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course discusses different aspects of materials used for energy generation and storage and their impact on environment including life cycle assessment and disposal methods.

Course Contents:

Introduction. Green and sustainable technologies on materials manufacturing and processing. Introduction and applications of natural rubber, clay minerals and begasse & cellulose materials. Energy cost of materials; materials for thin-film photovoltaics. Materials for energy storage; hydrogen and batteries. Materials for power generation. Origin, life cycle assessment and their effects on environment and disposal methods; wind, hydal, steam engines, electric engines, combustion engines, electric car and nuclear energy. Ceramics for energy conversion systems; ceramic matrix composites and silicon carbide for energy applications. Ceramics in environmental applications. Carbon dioxide capture, conversion and sequestration; materials and processes. Energy and water; impact on current & future water stress in Pakistan.

Reference Books:

1. Tatsuki Ohji, Josef Matyas, Henry Colorado, Raghunath Kanakala. Advances in Materials Science for Environmental & Energy Technologies VI. Wiley.
2. Raj Mohan B., G. Srinikethan. Bhim Charan Meikap. Materials, Energy & Environment Engineering: Select Proceedings of ICACE.
3. Springer,.
4. Kobayashi, Takaomi. Applied Environmental Materials Science for Sustainability. IGI Global,.
5. Gilbert Rios, Gabriele Centi, Nick Kanellopoulos. Nanoporous Materials for Energy & the Environment. CRC Press,.

Course Title: Biological Materials

Course Code: MME631

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to identify, define and explain the biological materials and their properties, and to apply knowledge in conducting various experimental and design techniques in determining the different properties of biological materials.

Course Contents:

Evolution of materials science and engineering, self-assembly, hierarchy and evolution, introduction to biological and bioinspired materials, biopolymers, cells, bio-mineralization. Biological materials; silicate and calcium carbonate-based composites, calcium phosphate-based composites, biological polymers and polymer composites, biological elastomers. biological foams. functional biological materials. Bioinspired materials, molecular-based biomimetic. Biopolymers: proteins and polysaccharides, bio-mineralization, bio-composites, bio fabrication. Biogenesis, enzymes, and cells at work. Manufacturing and processing of biomaterials; chemical synthesis, coatings, total hip joint, and knee joint replacement implants. Biomechanical properties of biological materials, experimental tools for determining the structure of biological materials, characterization of hiomaterials, hiomimetic material design, structure-property relationship in biological materials; XRD, SEM, TEM. Design and function of structural biological materials, analysis of biological materials.

Reference Books:

1. Pecheva E. Study of Biocompatiblc & Biological Materials: Can they be influenced by external factors9 Materials Research from LLC.
2. Ahmed J., Rahman S. Mohammad. & Roos H. Y,:jo. Glass Transition & Phase Transitions in Food & Biological Materials. John Wiley & Sons,.
3. Elices M. Structural Biological Materials: Design & Structure-Property Relationships. Elsevier,.
4. Gremlich U-H., Yan B. Infrared & Raman Spectroscopy of Biological Materials. CRC Press,.

Course Title: Surface Engineering

Course Code: MME641

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide a comprehensive knowledge to solve concrete problems of surface engineering. It also gives an understanding of methods and technologies for surface treatments.

Course Contents:

Concept of surface engineering. Properties of solid surfaces; tribological properties, optical properties, electric & opto-electronic properties and corrosion. Emergence of interfacial engineering. Coatings; organic coatings, ceramic coating & linings. nanostructured coatings. hot dip coatings, weld-overlay coatings and thermal spray coatings. Physical vapor deposition; thermal & electron beam evaporation, ion treatment in thin-film deposition, ion plating, planar diode and planar magnetron sputtering and ion beam sputtering. Chemical vapor deposition; plasma enhanced chemical vapor deposition, atomic layer deposition and pulsed layer deposition. Nucleation and growth of thin films. Nitriding, boriding and carburizing, Ion implantation of surface engineering. Current and future applications of surface engineering in Pakistan.

Reference Books:

1. Martin P. Introduction to Surface Engineering & Functionally Engineered Materials. Wiley. 201.
2. Xu Z. & Xiong F.F. Plasma Surface Metallurgy. Springer,.
3. Kanematsu H. & Barry D.M. Corrosion Control & Surface Finishing. Springer,.
4. Cavaleiro A. & De Hosson J. T. M. Nanostructured Coatings. Springer Science plus Business Media,.

Course Title: Corrosion Engineering

Course Code: MME651

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The course aims to provide an understanding of the corrosion principles and engineering methods used to minimize and prevent the corrosion.

Course Contents:

Basics of corrosion engineering, electrochemistry of the process of corrosion, high-temperature oxidation of metal and alloys, pourbaix diagrams, corrosion thermodynamics, a kinetic study of corrosion and polarization processes. Types of corrosion; pitting and crevice corrosion, stress-corrosion cracking, galvanic corrosion, erosion-corrosion, intergranular corrosion. microbiologically influenced corrosion, cavitation damage, corrosion fatigue and fretting corrosion. Passivity; types, operational conditions for passivation, a kinetic study of passivity. Methods for corrosion control: cathodic protection, anodic protection, metallic, inorganic and organic coatings, inhibitors and passivators. Materials selection; factors affecting the materials performance, material selection process, classification of materials, ranking of the performance of materials, electrolyte factors, corrosion indices, selection of materials for corrosive environments. Corrosion testing, and monitoring; AC and DC techniques. Effects of corrosions on materials and environment; environment-sensitive cracking, mechanisms of environment-sensitive cracking, practical aspects of environment-sensitive cracking.

Reference Books:

1. Desario, R. Corrosion Engineering: An Introduction. Willford Press,.
2. Cicek, V. & B. Al-Numan. Corrosion Engineering & Cathodic Protection Handbook: With Extensive Question & Answer Section. Wiley,.
3. Revie, R.W. Corrosion & Corrosion Control: An Introduction to Corrosion Science & Engineering. Wiley,.
4. Zaki Ahmad. Principles of Corrosion Engineering & Corrosion Control. Elsevier Science & Technology Books,.

Course Title: Special Topics in Materials Engineering

Course Code: MME661

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To develop awareness and indulge in specific research activities To develop strong industry-academia linkage

Course Contents:

A series of lectures by renowned researchers in the field and by Industrial experts shall be conducted. It is an attend only course with either Pass or Fail grading status as per attendance rules and regulations ofCIIT. There shall be field trips, research projects, presentations and report writing. List of journals, experts and speakers shall be finalized by the graduate research committee.

Reference Books:

Course Title: Advanced Process Systems Engineering

Course Code: PSE601

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course intends to help the students to develop the capability of systems thinking by introducing classical and advanced systems engineering theory, methods, and tools, develop a systems engineering plan for a realistic project, understand the applicability of any proposed process, strategy, or methodology for systems engineering , understand system engineers' role and responsibilities and apply systems engineering tools (e.g., requirements development and management, robust design, Design Structure Matrix) to realistic problems.

Course Contents:

Definition and characteristics of a System. Multiple, heterogeneous and distributed systems. Systems Engineering vs. Product Development. Systems engineering as human activity. Stakeholder analysis and requirements. Critical parameter development and management. Innovation in Systems Engineering. Axiomatic Design and DM-DSM Method. Trade Space Exploration and Concept Selection. Robust Design. Design Verification, Validation, reliability and Lifecycle Management.

Reference Books:

1. Blanchard, B. S., and Fabrycky, W. J., Systems Engineering and Analysis, ((5th ed.)), Prentice Hall, (2010).
2. INCOSE Systems Engineering Handbook, v3.2. San Diego, CA: INCOSE, (2010).
3. Miller, John. The Question behind the question: Practicing Personal Accountability at Work and in Life. East Rutherford, NJ: Putnam Publishing Group, (2004). ISBN: 9780399152337.
4. Altshuller, Genrich, Dana W. Clarke, Uri Fedozeev, and Steve Rodman. 40 Principles: TRIZ Keys to Innovation. Worcester, MA: Technical Innovation Center, Inc., (2005). ISBN: 9780964074057.

Course Title: Advanced Process Control

Course Code: PSE610

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide in depth understanding of process control practices applied in process industries and its applications in process control systems.

Course Contents:

Process models (Mechanistic, Black Box, Qualitative and Statistical models). Linear Process control theory and Practice concerned with the modeling of processes for control, linear control systems design and analysis, control loop elements & control loop tuning and multi-loop control systems. The course is supported by process control design assignments involving application tools, where the students will design control loop strategies and evaluate them through the simulation packages.

Reference Books:

1. Luyben, Plant Wide process Control, (1999) McGraw Hill.
2. Coughanowr, D.R, (1991), Process Systems Analysis and Control ((2nd ed.)) McGraw Hill.
3. Kuo, B. & Hanselman, MATLAB Tools for Control Systems Analysis and Desig, (1994) Prentice Hall.
4. Luyben, W. L, Process Modeling, Simulation and Control for Chemical Engineers, ((2nd ed.)), (1989), McGraw Hill.
5. Ogata, K. Solving Control Engineering Problems in MATLAB, (1994), Prentice Hall.
6. Wiley Seborg, D. E., Edgar, T.F.& Mellichamp Process Dynamics and Control, ((2nd ed.)), (1989), Prentice Hall.

Course Title: Advanced Process Economics

Course Code: PSE651

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Developing master graduates capable to fulfill demands of the jobs featuring multidisciplinary activities in process engineering, process informatics .Also abilities for performing design, research, optimization, advanced control and innovation activities.

Course Contents:

Process Economics - Economic feasibility of project using order of magnitude cost estimates, Plant and equipment cost estimation, Product cost Estimation. Cash Flows - Time value of money, investment, costs, sales, profits, taxes, depreciation. Profitability Analysis - Rate of return, payback period, discounted rate of return, net present worth, internal rate of return, Comparing investment alternatives. Conceptual Process Synthesis. Maximum Energy Recovery design, Evolutionary synthesis for minimum number of exchangers design, super targeting, Heat and Power Integration, Integration of heat exchanger network with distillation columns.

Reference Books:

1. Seider, W.D., Seader, J.D. and Lewin, D.R. Process Design Principles - Synthesis, Analysis and Evaluation, (1999), John Wiley and Sons Inc.
2. Biegler, L.T., Grossmann, I.E., and Westerberg, A.W. Systematic Methods for Chemical Process Design, (1997), Prentice-Hall.
3. Smith, R., Chemical Process Design, (1995), McGraw-Hill.
4. Peters, M.S. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, (1980), McGraw-Hill.
5. Baasel, W.D. Preliminary Chemical Engineering Plant Design, Van Nostrand Reinhold, (1990), (2nd ed.), Van Nostrand Reinhold Co., New York.
6. Douglas, J.M., Conceptual Design of Chemical Processes, (1988), McGraw-Hill.

Course Title: Process Integration

Course Code: PSE702

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide an understanding of process integration (PI) with regard to energy efficiency, waste minimization and an efficient use of raw materials to communicate the principles of PI, provide recommendations for process design and implementation, and to apply these principles and recommendations to PI processes/problems.

Course Contents:

Introduction: Introduction to Process Integration, Importance of Process Integration and applications in Chemical Industries, Overview of Process Integration. Heat Exchanger Networking: Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve (GCC), Area Targeting by Uniform Bath formula and Unit Targeting by Eulers' formula, Heuristics for Pinch Design, Maximum Energy Recovery Design, Evolution of Network. Reactor Integration: Choice of Idealized reactor model and reactor performance. Reactor configurations; Temperature Control, Gas-Liquid and Liquid-Liquid Reactors, Choice of Reactors. Heat Integration characteristics of reactors, Appropriate placements of reactors. Use of GCC for Heat Integration of reactors. Distillation Integration: Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column. Mass Exchanger Network Synthesis: Mass Exchanger Network, Minimum Mass Separating Agents (MSA), Mass exchange networks for minimum external MSA. Minimum Number of Mass Exchangers.

Reference Books:

1. Mahmoud M. El-Halwagi, Process Integration, ((1st ed.)), Academic Press, (2006).
2. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi, (2005).
3. Warren D. Seider, J. D. Seader and Daniel R Lewin, Product & Process Design Principles, ((2nd ed.)), John Wiley and Sons. Ltd. (2004), ISBN 0-471-21663-1.
4. Uday V. Shenoy, Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Publication, (1995).

Course Title: Process Design and Optimization

Course Code: PSE720

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide an understanding of the technology available to design and optimize process systems, business models and operations with state-of-the-art versions of modelling and optimization approaches in order to understand both the potential and the limitations of available techniques.

Course Contents:

System characterization: Identification of objectives, design variables, constraints, subsystems, System-level coupling and interactions, Examples of MSDO in practice, Visualization techniques in design optimization. Subsystem model development: Model partitioning and decomposition, interface control, Collaborative Optimization, Bi-Level Formulations, Subsystem model selection: fidelity versus expense, Model and simulation development and validation. Optimization and exploration techniques: Review of linear and nonlinear programming, Heuristic techniques: genetic algorithms simulated annealing, Tabu search, Design of Experiments (DOE): Full factorial search, parameter study, Taguchi/orthogonal arrays, latin hypercubes, Mixed integer programming (application to hub spoke / network problems). Sensitivity and post-optimality analysis: Jacobian matrix, Hessian, finite differences, Adjoint methods and Lagrange multipliers. Multiobjective optimization: Weighted sum optimization, Weak and strong dominance, Pareto front computation, Goal programming and isoperformance, Physical Programming, Multiattribute Utility Theory. System assessment and extensions: optimality, Design for value: including lifecycle costing, Optimizing product families and platforms. Implementation issues: Model reduction, Approximation techniques: response surfaces, kriging, neural networks, Concurrent design

Reference Books:

1. Biegler, Grossmann and Westerberg, Systematic Methods for Chemical Process Design (Part II), Prentice Hall, (1997).
2. Panos Y. Papalambros and Douglass J. Wilde, Principles of Optimal Design – Modeling and Computation, ((2nd ed.)), , Cambridge University Press, (2000), ISBN 0 521 62727 3.
3. R. E. Steuer. Multiple Criteria Optimization: Theory, Computation and Application. Wiley, New York, (1986).
4. David E. Goldberg, Genetic Algorithms – in Search, Optimization & Machine Learning, Addison –Wesley, (1989), ISBN 0 201 15767-5.
5. Bazaraa, M.S., H.D. Sherali and C.M. Shetty, Nonlinear Programming, John Wiley (1992).
6. Edgar, T.F. and D.M. Himmelblau, Optimization of Chemical Processes, McGraw Hill (2001).

7. Hillier, F.S. and G.J. Lieberman, Introduction to Operations Research, Holden Day (1986).
8. Minoux, M., Mathematical Programming: Theory and Algorithms, John Wiley (1986).
9. Reklaitis, G.V., A. Ravindran and K.M. Ragsdell, Engineering Optimization - Methods and Applications, John Wiley (1983).
10. Williams, H.P., Model Building in Mathematical Programming, Wiley-Interscience (1978).
11. Westerberg, A.W., H.P. Hutchinson, R.L. Motard, P. Winter, Process Flowsheeting, Cambridge University Press (1985).

Course Title: Process Modeling and Simulation

Course Code: PSE731

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course provides an overview of modeling and simulation techniques and addresses the role of modeling and simulation in the systems engineering process and provides methods for architecting and managing the development of complex models/simulations. The course introduces students to important design considerations for the development of complex distributed software simulations and frameworks.

Course Contents:

Introduction: Definitions of Modeling and Simulation, Modeling and simulation techniques, Applications, Discrete vs. Continuous time, Process flow in simulation study. Queuing systems, Communications networks, Event-driven simulation, List processing. Simulation software: Selection process, Simulation in High Level Language (C, C++), Simulation packages (Matlab/Simulink/Hysys), Interpreted vs. compiled simulators. Statistical models: Useful Statistical Models, Distributions, Queuing models,. Characteristics, Performance Measures, Steady-State Behavior, Networks of Queues. Random Number Generation: Properties of Random Numbers, Generation of Pseudo-Random Numbers, Testing for Randomness, Pitfalls, Random Variate Generation, Inverse Transform, Direct Transform, Convolution, Accept-Reject. Input Modeling: Data Distributions, Histograms, Parameter Estimation, Goodness-of-Fit, Selecting Input Model without Data. Verification and Validation of Simulation Models: Model Building, Verification of Simulation Models, Calibration and Validation of Models. Output Analysis: Types of Simulations with Respect to Output Analysis, Stochastic Nature of Output Data, Measures of Performance, Output Analysis for Termination Simulations, Output Analysis for Steady-State Simulations.

Reference Books:

1. Law M, Kelton W, Simulation Modeling and Analysis. McGraw-Hill, New York, NY, (2000).
2. Madachy R. Software Process Dynamics, Wiley/IEEE Press, (2007).
3. B. Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall, NJ, (1998).
4. W.Fred Ramirez, Computational Methods for Process Simulation, ((2nd ed.)), Betterworthus and Heinemann, Oxford, (1997).
5. Khoshnevis B, Systems Simulation - Implementations in EZSIM. McGraw-Hill, New York, NY, (1992).
6. William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, ((2nd ed.)), , McGraw Hill, (1990).

7. Westerberg, A.W., H.P. Hutchinson, R.L. Motard, P. Winter, Process Flowsheeting, Cambridge University Press (1985).

Course Title: Artificial Neural Network

Course Code: PSE732

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This Course aims to provide a theoretical and highly rigorous treatment of machine learning, Artificial Neural Networks (ANN) including single and multi-layer, fully-connected perceptions with simplified error analysis and backpropagation, starting at the most fundamental level. The course will also teach students about industrial and academic applications of neural networks and how to recognize tasks that ANN are suitable for.

Course Contents:

Introduction to ANN, Basics of ANN, Backpropagation networks (BPN, Activation & Synaptic Dynamics, Basic functional units of ANN for pattern recognition tasks, Feedforward neural networks, Feed back neural networks, Competitive learning neural networks, Applications of ANN in industrial processes, MATLAB programming for ANN problems.

Reference Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (((3rd ed.))), Pearson Education Ltd., USA, (2014).
2. Simon S. Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall, (1999).
3. Sun Yuan Kung, Digital Neural Networks, Prentice Hall, (1993).

Course Title: Sustainable Energy Systems

Course Code: PSE740

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This aims to assess current and potential future energy systems, covering resources, extraction, conversion, and end-use technologies, with emphasis on meeting regional and global energy needs in the 21st century in a sustainable manner including various renewable and conventional energy production technologies, energy end-use practices and alternatives, and consumption practices in the context of engineering, political, social, economic, and environmental goals.

Course Contents:

Energy sources for a more sustainable future, Overview of energy use and related issues, Major energy options; issues of supply and demand, Overview of units and dimensions for global energy flows (Quads, MMBOE, MW, EJ, etc.); energy conversions (chemical to thermal, chemical to electric, etc.); and economic considerations, Climate Change; Science, Economics, and Policy. Energy transfer and conversion methods, Energy and Sustainability (Clean Technologies), Energy sustainability issues; Energy footprints, Opportunities and barriers; timing issues, Drivers of change. Resource evaluation and depletion analyses, Energy conversion, transmission, and storage, Energy supply, demand, and storage planning, Power systems dynamics, Energy end use, option assessment, and tradeoff analysis

Reference Books:

1. McKay, David J. C. Sustainable Energy – Without the Hot Air. UIT Cambridge, Ltd., (2009). ISBN: 9780954452933.
2. Randolph, John, and Gilbert M. Masters. Energy for Sustainability: Technology, Planning, Policy. Island Press, (2008). ISBN: 9781597261036.
3. Bisio, Attilio, and Sharon Boots. Wiley Encyclopedia of Energy Technology and the Environment. Wiley-Interscience, (1996). ISBN: 9780471148272.

Course Title: PINCH Technology

Course Code: PSE741

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course covers the key concepts of heat and water pinch analysis and is designed to serve as an introduction to methods likely to be of use to practicing graduates in chemical engineering. Emphasis is on the development of specific quantitative skills that will be useful in a wide range of processes.

Course Contents:

Introduction, Key concepts of Pinch analysis, Data extraction and energy targeting, HEN Design Utilities, heat and power systems, Process change and evolution, Batch and time dependent processes, Applying the Technology in Practice, Case Studies.

Reference Books:

1. Ian C Kemp, Pinch Analysis and Process Integration, ((2nd ed.)), Elsevier Publication, (2007).
2. Mohmoud Bahy Noureddin, Pinch Technology and Beyond Pinch, New Vistas on Energy Efficiency Optimization, Booktopia, (2011).
3. Lorenz T Biegler, Ignacio E Grossmann and Aurthur W Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, (1997).

Course Title: Energy Audit and Management

Course Code: PSE742

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

This course aims to provide the background required for engineers to meet this role and to equip the students with the skills and techniques required to implement energy management.

Course Contents:

Energy Scenario; Energy Management & Energy Planning; Energy Audit and Energy Monitoring, Targeting and Conservation; Advancement In Technologies and Future Energy Alternatives; Recent advancement in energy; Fusion; Biomass; Geothermal energy; Case Studies: Energy conservation in alcohol industry, fertilizer industry, and pulp and paper industry, Energy conservation in different units of refinery.

Reference Books:

1. Murphy W.R. and Mckay G., Energy Management, Elsevier, (2007).
2. Roger A. Hinrichs and Merlin H. Kleinbach, Energy: Its Use and the Environment, Cengage Learning, (2012).
3. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, (7th ed.), Keinnedu Fairmant Press, (2011).

Course Title: Fundamental of Polymer Science and Technology

Course Code: PST611

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge of fundamental concepts Polymer science and Technology.

Course Contents:

Introduction to basic concepts of polymer science and technology. Polymer classification, Relationship of molecular conformation, structure and morphology to physical and mechanical properties, molar masses concept in polymers; Fundamental of polymer solution and fundamental forces in polymer system; Molecular theories of polymer system; Physics of amorphous and crystalline polymers. Transition temperature and free volume of polymers.

Reference Books:

1. Joel Fried, "Polymer Science and Technology (2nd ed.)", 2014.
2. Robert J. Young, Peter A. Lovell, "Introduction to Polymers" (3rd ed.), 2011
3. Anil Kumar and Rakesh K. Gupta, "Fundamentals of Polymer Engineering, Revised and Expanded (Plastics Engineering)", (2003).

Course Title: Polymer Processing Technologies

Course Code: PST621

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The objective of the course is to provide knowledge about the polymer processing operations. The fundamentals of the processing machines will be illustrated by focusing on some of the important thermoplastic polymer processing machines.

Course Contents:

Processing Fundamentals, Rheology of Polymers, Description of the physical, thermal, mechanical, and rheological properties of polymeric materials relevant to their processing behavior. Introduction to various processing technologies for the manufacture of polymeric articles, with particular emphasis on: extrusion, injection molding, blow molding, thermoforming, and compression molding.

Reference Books:

1. Tim A. Osswald and Osswald, "Polymer Processing Fundamentals", 1998 R.G. Griskey, "Polymer Process Engineering", Chapmen and Hall, 1995
2. Harold Belfosky, Hanser Gardner, "Plastics Product Design and Process Engineering", CRC Press, 1995
3. J.L. Throne, "Technology of Thermoforming", Hanser Gardner Publications, 1995
4. Harold Belfosky, Hanser Gardner, "Polymer Processing: Principles and Design", Wiley, (2015).

Course Title: Elastomers Technology

Course Code: PST622

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge about elastomer types, their structure, properties, processing and applications. It will also enable students to Analyze material property data and how this information can be utilized in terms of estimating certain material's performance and durability in a specific application.

Course Contents:

Critical examination of new elastomers and thermoplastic elastomers appearing in the current research literatures. Studies of new elastomers and thermoplastic elastomers in terms of their compositions, morphology, properties, and applications. Innovation of fabrication process for new elastomers and thermoplastic elastomers.

Reference Books:

1. Jovan Balcazara and Edgardo Paules, “Elastomers: Types, Properties and Applications (Materials Science and Technology)”, 2011
2. Dariusz M. Bielinski, Ryszard Kozlowski, Gennady E. Zaikov, “High Performance Elastomer Materials: An Engineering Approach”, 2014
3. Laurence McKeen, “Permeability Properties of Plastics and Elastomers”, 2011
4. Anil K. Bhowmick, Howard Stephens, “Handbook of Elastomers (2nd ed.)”, 2000
5. I. Franta, “Elastomers and Rubber Compounding Materials”, (1989).

Course Title: Polymer Blends and Composites

Course Code: PST623

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the understanding of synthesis, morphology, and mechanical behavior of polymer blends and composites. To provide knowledge about advantages of nano-composites over conventional composites, mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers.

Course Contents:

Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized.

Reference Books:

1. James C. Gerdeen PhD PE and Ronald A.L. Rorrer, "Engineering Design with Polymers and Composites (2nd ed.)", 2011
2. József Karger-Kocsis, Stoyko Fakirov, "Nano- and Micro-mechanics of Polymer Blends and Composites", 2009
3. Long Yu, "Biodegradable Polymer Blends and Composites from Renewable Resources",2009.
4. Krishan K. Chawla, "Composite Materials: Science and Engineering (Materials Research and Engineering) (3rd ed.)", (2012).

Course Title: Polymer Textile Fibers

Course Code: PST629

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge of production methods of fibres of both natural and synthetic polymers, flow behavior of polymeric materials as related to the formation of fibers by melt, dry and wet extrusion and products with improved features, develop techniques of filling, plasticizing and coating.

Course Contents:

Flow behavior of polymeric materials as related to the formation of fibers by melt, dry and wet extrusion. Elementary theories of drawing and heat setting. Application of fiber-forming theories to synthetic and natural fibers. Topics in textile fibers wet processing. Topics in coloration of textile fibers; chemical and physical mechanisms in textile dyeing and printing. Application of analytical techniques for analysis to fibers, textile chemicals and textile processes; atomic absorption, ultraviolet, visible, near-infrared and infrared spectrophotometer; chromatography; interfacial tension; calorimetric, gravimetric and complex metric analyses.

Reference Books:

1. Mishra, S.P., “A Textbook of Fibre Science and Technology (1st ed.)”, 2017
2. Textile Institute, “Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin (1st ed.)”, 2005
3. Jacqueline I. Kroschwitz, “Polymers: Fibers and Textiles (1st ed.)”, (1990).

Course Title: Polymer Chemistry

Course Code: PST631

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide in-depth knowledge of the most timely and extensively researched areas of polymer chemistry. All the topics aim at producing novel, functional and advanced polymer materials.

Course Contents:

Introduction to the synthesis of polymers and the mechanism of polymerization processes. Fundamental principles of polymer chemistry. Step-growth polymerization and network formation (theory of gelation). Chain-growth homo-polymerization and copolymerization by radical-, ionic-, and coordination type catalysts. Synthesis of block and graft copolymers. Structure of polymers and their application. Polymers and the environment, polymer recycling

Reference Books:

1. Hiemenz and Lodge, “Polymer Chemistry”, (2nd ed.), CRC Press, 2017
2. Odian, “Principles of Polymerization”, (4th ed.), Wiley, 2014,
3. Ferdinand Rodriguez, “Principles of Polymer Systems”, McGraw-Hill Inc. US; 2nd Revised edition, (1983).

Course Title: Engineering Behavior of Polymers

Course Code: PST641

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the knowledge about mechanical behavior and characterization of polymer's viscoelastic response with the aid of mechanical model analogs. To provide knowledge about Time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, effects of different fillers, plasticizers, moisture, and aging on mechanical behavior of Polymers.

Course Contents:

It deals with mechanical behavior of polymers. Characterization of viscoelastic response with the aid of mechanical model analogs. Time-temperature superposition, experimental characterization of large deformation, and fracture processes, polymer adhesion. Effects of fillers, plasticizers, moisture, and aging on mechanical behavior.

Reference Books:

1. Properties and Behavior of Polymers 2 (1st ed.)", 2011
2. Tim A. Osswald, Georg Menges, "Materials Science of Polymers for Engineers", 2012
3. Anil Kumar, Rakesh K. Gupta, "Fundamentals of Polymer Engineering, Revised and Expanded", 2003
4. G.M. Swallowe, "Mechanical Properties and Testing of Polymers (3rd Volume)", (1999).

Course Title: Characterization and Testing of Polymeric Materials

Course Code: PST651

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the knowledge of recent development of functional polymers and their range of applications, advanced structural and functional property characterization techniques, polymer structure property relationship and polymer testing.

Course Contents:

This course introduces the fundamental theoretical framework for diffraction, spectroscopy and imaging methods used in the structural and compositional characterization of engineering materials. The laboratory portion of the course offers intensive instruction in the most widely practiced x-ray diffraction (XRD) methods for materials evaluation, and an introduction to electron microscopy using a scanning electron microscope (SEM) an energy dispersive spectrometer (EDS), and a transmission electron microscope (TEM), chromatography, infrared spectroscopy, UV/Vis spectroscopy, atomic absorption spectroscopy. Moreover, this course also emphasis on Mechanical testing, Thermal testing, Chemical testing and Electrical testing of polymeric materials. The course will include several visits to the materials lab and an experimental term project.

Reference Books:

1. Wiley, "Characterization and Analysis of Polymers" John Wiley Publications, 2008 Elsevier "Membrane Characterization", Elsevier B.V. publication, 2017.
2. J.P. Eberhart, "Structural and Chemical Analysis of Materials", John Wiley Publication, (1992).

Course Title: Polymeric Coatings

Course Code: PST653

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge about production technology and properties of polymeric coatings, selection of the appropriate coating components and its application. Also, it provide knowledge about waterborne, high-solids and powder coatings that comply with quality, VOC, and regulatory standards.

Course Contents:

Principles of film formation, synthesis, structure-property relationships, coatings solvents; pigments and their dispersion. Physical properties of coatings and their components; formulation, design, testing and applications; color, adhesion and rheology; Design and formulation of waterborne, high-solids and powder coatings that meet current VOC regulations.

Reference Books:

1. Vikas Mittal, “Polymer Nanocomposite Coatings”, 2016
2. Limin Wu, Jamil Baghdachi, “Functional Polymer Coatings: Principles, Methods, and Applications”, 2015
3. Refika KURBANLI, Gülnare AHMETL and Alaaddin CERT, “Polymeric Coatings: Production, Characterization and Applications”, 2011
4. Rose A. Ryntz (Editor), Philip V. Yaneff, “Coatings of Polymers and Plastics (Materials Engineering, 21) (1st ed.)”, (2003).

Course Title: Special Topics in Polymer Science and Technology

Course Code: PST655

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge about new plastics processing techniques appearing in research literature and being commercialized in the plastics industry, key processing methods applied in the production of plastics products, different types of moulds, tooling and design of plastic products including the equipment, tooling, and environment required for their production. Apart from this a wider range of polymer processes: thermoforming, compression and transfer moulding, rotational moulding, sintering, blow moulding, assembling techniques will be covered

Course Contents:

Critical examination of synthesis and characteristic of new polymers appearing in research literature and being commercialized in the plastics industry. plastics as well as processing techniques appearing in research literature and being commercialized in the plastics industry. Specific topics including muti-material injection molding technology, muti-layer material technology and advanced blow molding. Theory and design of polymer processing machinery including hydraulic and electrical control circuits, machine logic, drives, pumps, and motors. Heating barrel and screw combinations

Reference Books:

1. Muralisrinivasan Natamai Subramanian, “Polymer Blends and Composites: Chemistry and Technology”, 2017
2. Deepak Langhe, Michael Ponting, “Manufacturing and Novel Applications of Multilayer Polymer Films”, 2016
3. Visakh P. M., María José Martínez Morlanes, “Nanomaterials and Nanocomposites: Zero- to Three-Dimensional Materials and Their Composites”, 2016
4. Vijay Kumar Thakur, Michael R. Kessler, “Liquid Crystalline Polymers (1st ed.)”, 2015 Benjamin M. Walker, Charles P. Rader, “Handbook of Thermoplastic Elastomers”, 1988
5. C. Craver and C. Carraher, “Applied Polymer Science: 21st Century (1st ed.)”, 2001 Gennady E. Zaikov (Editor), Liliya I. Bazylyak (Editor), Jimsher N. Aneli, “Polymers for Advanced Technologies: Processing, Characterization and Applications”, 2013
6. Dominick V. Rosato, Andrew V. Rosato, David P. Di Mattia, “Molding Operation, Blow Molding Handbook: Technology, Performance, Markets, Economics: the Complete Blow”, (2004).

Course Title: Polymeric Biomaterials

Course Code: PST661

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The subject aims to provide knowledge about types of bio-based polymeric materials their material properties, functions required for medical and environmental applications. To provide knowledge about different approaches to design biomaterial and interfacial behavior of molecules near biomaterials.

Course Contents:

Important classes of polymeric biomaterials, material preparation, processing, properties and applications. Topics will include silicone elastomers, degradable hydrogels, ultra-high molecular weight polyethylene, polyurethanes, polyesters, and biopolymers such as silks and collagen, novel bioactive dressing for wound healing applications, identification of methods for the testing of polymeric biomaterials.

Reference Books:

1. Severian Dumitriu, “Polymeric Biomaterials: Structure and Function (1st ed.)”, 2011
2. Sabu Thomas, Preetha Balakrishnan, M.S. Sreekala, “Fundamental Biomaterials: Polymers,” 2018;
3. Severian Dumitriu, “Polymeric Biomaterials, Revised and Expanded”, (2001).

Course Title: Environment Impacts of Plastics and Recycling Technologies

Course Code: PST671

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

Introducing students to different plastic production processes and direct impact on human, animal and aquatic life due to emissions, waste and different domestic/household/commercial applications. Introducing students to the importance of recycling in general, and especially with the polymers recycling in terms of saving raw materials, energy and also for environmental protection. Student will learn to Identify primary and secondary recycling methods, Analyze various tertiary and quaternary recycling methods and Understand recycling methods of various plastics

Course Contents:

Introduction, Advantages and disadvantages of Plastics, Types and Disposal of Plastics International regulations regarding plastic industries, International Regulations of Plastic industry, Regulation of Plastic Industry in Pakistan, Types of plastic pollution, Environmental Impacts of plastics, Harm to Marine Wildlife, Ingestion of plastics, Entanglement in plastic debris, The Causes and Effects of the use of Disposable Plastics, Toxicity Impact of Plastic Bags and Water Bottles. Plastic waste, polymer waste recycling, use of waste polymeric materials for energy products, introduction to the principles of polymers degradation, technologies for degradation and recycling of polymers/elastomers waste, sources of plastic waste and its management, waste management, separation methods to sort out and resize polymer waste, primary & secondary methods of recycling, tertiary & quaternary recycling methods, recycling of specific polymer like PVC, PET, PMMA, HDPE , LDPE , PS.

Reference Books:

1. François Galgani, Christopher K. Pham, Julia Reisser, “Plastic Pollution” Frontier Media, 2017
2. ChuanchomAumnate, Natalie Rudolph, and Raphael Kiesel, “Understanding Plastics Recycling: Economic, Ecological, and Technical”, 2017
3. Geof Knight, “Plastic Pollution”, 2012 Susan Freinkel, “Plastic: A Toxic Love Story” 2011
4. Vannessa Goodship, “Introduction to Plastics Recycling” 2007
5. Bruce Hegberg, Gary R. Brenniman, and William H. Hallenbeck ”Mixed Plastics Recycling Technology”, 1992
6. Francesco La Mantia, “Handbook of Plastics Recycling”, (2002).

Course Title: Polymer Process Machinery Technology

Course Code: PST724

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

The subject aims to provide knowledge about new polymer processing machineries, critical features of new polymer processing machineries launched by leading companies in the plastics industry in the recent years. It will also enable students to compare advantages, improvement, and limitations of new machineries.

Course Contents:

Discussion oriented course focusing on the new polymer processing machineries presented in the world-class exhibitions including National Plastics Exhibitions (NPE) in USA and K-Plast in Germany. Reviewing critical features of new polymer processing machineries launched by leading companies in the plastics industry in the recent years. Comparing advantages, improvement, and limitations of new machineries.

Reference Books:

1. Natamai Subramanian Muralisrinivasan, “Introduction to Polymer Compounding: Machinery and Technology”, 2015
2. Chris Rauwendaal, “Polymer Extrusion 4E (4th ed.)”, 2001
3. NIIR Board, “Modern Technology of Plastic & Polymer Processing Industries”, 2003; R. Griskey, “Polymer Process Engineering (1st ed.)”, (1995).

Course Title: Advanced Polymer Processing

Course Code: PST725

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge of advanced polymer processing techniques & effect of computer aided tools in production efficiency.

Course Contents:

Polymer processing including injection molding and extrusion. Polymer Rheology and Non-Newtonian luid mechanics. Melting of Polymers, Pressurization and Pumping mechanism during Processing of polymers, Mixing of Polymers during processing of Polymers, Single and twin rotors Machines, Die forming, Injection Molding, Design and analysis of polymer products and processing based on knowledge of the composition, physical properties and rheological behavior of the. Case studies of transport phenomena approaches on polymer conversion process analysis in rolled blown film extrusion and polymer-additive mixing. . Topics include pressurization, pumping, die forming, calendering, coating, molding, fiber spinning and elastic phenomena.

Reference Books:

1. Nicholas P. Cheremisinoff, “Advanced Polymer Processing Operations (1st ed.)”, 1999
2. Sabu Thomas, Deepalekshmi Ponnamma, Ajesh K. Zachariah, “Polymer Processing and Characterization”, 2012
3. Tim A. Osswald, Juan Pablo Hernández-Ortiz, “Polymer Processing: Modeling and Simulation”, 2006
4. Gennady E. Zaikov, Liliya I. Bazylyak, Jimsher N. Aneli, “Polymers for Advanced Technologies: Processing, Characterization and Applications”, (2013).

Course Title: Plastic Products Manufacturing

Course Code: PST726

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide knowledge about the key processing methods applied in the production of plastics products and parts. Subject will provide knowledge on production of plastic products including the equipment, tooling, and environment required for their production.

Course Contents:

An exploration of the science underlying polymer processes such as injection molding through a combination of theory development, practical analysis, and utilization of commercial software. Polymer chemistry and structure, material rheological behavior, processing kinetics, molecular orientation development, process simulation software development, manufacturing defects, manufacturing window establishment, manufacturing process design, manufacturing process optimization. Use of computer-aided engineering and design (CAE and CAD) in the product design and the analysis of product performance. Case studies of plastic production design.

Reference Books:

1. Suresh G. Advani and Kuang-Ting Hsiao, "Manufacturing techniques for polymer matrix composites (PMCs) (1st ed.) ", 2012
2. David Kazmer, "Plastics Manufacturing Systems Engineering: A Systems Approach", 2009
3. David O. Kazmer, "Plastics Manufacturing Systems Engineering", 2009
4. M. Joseph Gordon, "Industrial design of plastics products", 2003
5. Philip Mitchell, "Tool and Manufacturing Engineers Handbook: Plastic Part Manufacturing", (1996).

Course Title: Advanced Polymer Synthesis and Processes

Course Code: PST732

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the knowledge of fundamental background sciences to synthesis and processing of polymeric materials, types of polymerization, and synthetic processes.

Course Contents:

Polymer synthetic methods. Advanced catalyst system. Gel and network formation. Polymer interchanges polymerization. Group transfer polymerization. Metathesis polymerization. Plasma polymerization. Coordination polymerization. Transformation reactions. High performance polymers and their synthesis. Reactors for industrial polymerization processes. Control of polymerization reactors. Case studies of new polymer synthetic processes.

Reference Books:

1. Dietrich Braun, Harald Cherdron, Matthias Rehahn and Helmut Ritter, "Polymer Synthesis: Theory and Practice: Fundamentals, Methods, Experiments" (5th ed.), 2012
2. Dieter A. Schlüter, Craig Hawker and Junji Sakamoto, "Synthesis of Polymers (Materials Science and Technology: (A Comprehensive Treatment)", 2012
3. Robert J. Young, Peter A. Lovell, "Introduction to Polymers (3rd ed.)", (2011).

Course Title: Polymer Reaction Technology

Course Code: PST733

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the understanding of applying technological principles in analysis and design of polymerization processes. To enable students analyze heat and mass transfer, reactor dynamics and optimization and mixing effects during different polymer reactions. They will learn to perform mathematical modeling of polymerization kinetics, ideal polymerization reactors. To solve case studies of different polymer processes under changing reaction conditions.

Course Contents:

Technological principles applied to the analysis and design of polymerization processes. Mathematical modeling of polymerization kinetics, ideal polymerization reactors, heat and mass transfer, reactor dynamics and optimization, mixing effects. Case studies of important industrial processes.

Reference Books:

1. Jose Asua, “Polymer Reaction Engineering (1st ed.)”, 2007
2. Stoyko Fakirov, “Fundamentals of Polymer Science for Engineers”, 2017
3. James C. Gerdeen, PhD, PE, Ronald A.L. Rorrer, “Engineering Design with Polymers and Composites (2nd ed.)”, 2011
4. Robert O. Ebewele, “Polymer Science and Technolog”y, (2000).

Course Title: Advanced Polymer Characterization

Course Code: PST752

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide the knowledge of recent development of functional polymers and their range of applications, advanced structural and functional property characterization techniques, and the history of polymer processing and its influence on the structural and functional properties of these polymers.

Course Contents:

Polymer morphology-processing-property relationship. Deformation mechanisms and orientation characterization. Polymer characterization techniques for determination of thermal, physical and mechanical properties of polymers. Applications of light spectroscopy, x-ray scattering technique, scanning electron microscopy, and transmission electron microscopy to determine crystal structure and morphology of polymers. Application of Infrared (IR), Raman and Nuclear Magnetic Resonance (NMR) spectroscopy to determine microstructural features quantitatively. Case studies of current research in polymer structural analysis by polymer characterization technique.

Reference Books:

1. Dan Campbell, Richard A. Pethrick and Jim R. White, “Polymer Characterization: Physical Techniques (2nd ed.)”, 2000
2. Clara D. Craver and Theodore Provder, “Polymer Characterization: Physical Property, Spectroscopic, and Chromatographic Methods Advances in Chemistry, (2nd ed.)”, 2000
3. Rui Yang, “Analytical Methods for Polymer Characterization”, 2018 Rui Yang, “Polymer Surface Characterization”, 2014
4. B.J. Hunt, M.I. James, “Polymer Characterization”, (2012).

Course Title: Polymers Surfaces and Interfaces

Course Code: PST754

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide comprehensive knowledge about the principles that govern polymer phase behavior in bulk, thermodynamics of polymers in thin films and at interfaces and characterization techniques to assess polymer behavior in thin films and at interfaces. It will also enable students to Illustrate the morphologies of polymer thin films and other dimensionally-restricted structures relevant to polymer science and engineering.

Course Contents:

This course is designed for graduate students to gain a fundamental understanding of the surface and interfacial science of polymeric materials. Beginning with a brief introduction of the principles governing polymer phase behavior in bulk, it develops the thermodynamics of polymers in thin films and at interfaces, the characterization techniques to assess polymer behavior in thin films and at interfaces, and the morphologies of polymer thin films and other dimensionally-restricted structures relevant to polymer science and engineering. Field trips to national user facilities, laboratory demonstrations and hands-on experiments, and guest lectures will augment the course lectures.

Reference Books:

1. I, “Polymer Surface Characterization”, 2014
2. Manfred Stamm, “Polymer Surfaces and Interfaces: Characterization, Modification and Applications, (1st ed.)”, 2010
3. Isaac C. Sanchez, “Physics of Polymer Surfaces and Interfaces”, 2013
4. Richard A. L. Jones, Randal W. Richards, “Polymers at Surfaces and Interfaces”, (1999).

Course Title: Emulsion Polymers

Course Code: PST762

Credit Hours: 3(3, 0)

Pre-requisites: Nil

Course Objectives:

To provide knowledge of fundamental concepts important in the manufacture, characterization, and application of polymer latexes, polymerization mechanisms and kinetics of emulsion polymers, reactor design and characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups and film formation.

Course Contents:

Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems.

Reference Books:

1. Peter A. Lovell and Mohamed S. El-Amasser, Emulsion Polymerization and Emulsion Polymers, (1st ed.), 1997
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