RAMAIAH
Institute of Technology

CURRICULUM

Outcome Based Education

Academic year 2023 – 2024

CHEMICAL ENGINEERING

V & VI SEMESTER B.E.

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

About the Institute

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 17 UG programs and 11 PG programs. All these programs are approved by AICTE. All eligible UG and PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with **'A+' grade by NAAC in March 2021** for 5 years. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs since 2007. The institute has also been conferred autonomous status for Ph.D. program since 2021. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 67% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility for all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology, Centre for Antennas and Radio Frequency systems (CARFS), Center for Cyber Physical Systems, Schneider Centre of Excellence & Centre for Bio and Energy Materials Innovation. **Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 107 & world ranking 600 for the year 2022.**

The Entrepreneurship Development Cell (EDC) and Section 8 company "Ramaiah Evolute" have been set up on campus to incubate startups. **M S Ramaiah Institute of Technology is recognized by Atal Ranking of Institutions on Innovation Achievements (ARIIA), MoE, Govt. of India.** MSRIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. The Institute is a member of DELNET, CMTI and VTU E-Library Consortium. The Institute has a modern auditorium, recording studio, and several hi-tech conference halls with video conferencing facilities. The institute has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association.

As per the National Institutional Ranking Framework (NIRF), MoE, Government of India, Ramaiah Institute of Technology has achieved 78th rank among 1314 top Engineering Institutions & 23rd Rank among 105 School of Architecture in India for the year 2023.

About the Department

Instituted in 1978, the Department was the first to offer a course in Chemical Engineering by a self-financing engineering institution in Bangalore and the fifth in RIT. Since its inception the department has moved steadily towards the fulfilment of its mission and is emerging as a significant player in the academic landscape of Chemical Engineering education in our country. The Department is certified four times in succession by the National Board for Accreditation. Over 2000 students have graduated in 34 batches. The Department offers excellent infrastructure and students have won various prestigious awards, international internships and high accolades for innovative projects. The expertise of the faculty covers a wide range of disciplines and they are engaged in cutting edge technological research. The average experience of faculty in the department is more than twenty years and they are alumni of IISc, IIT and NITs. Enriching insights by eminent dignitaries from the practicing world are arranged under the activities of IIChE Student Chapter at the Institute. The Department is approved as Research Centre by VTU for higher qualifications like M.Sc. Engg. (By Research) and Ph.D. degrees. Research Projects from DRDO, AICTE and DST have been successfully completed. The Annual Technical Symposium organized by the department for students – RASAYAN encompasses a plethora of events such as Paper presentations, Poster presentations, M.S. Ramaiah Memorial Technical Quiz etc. to challenge the young minds. The Bangalore Regional Centre of the Indian Institute of Chemical Engineers is functioning from this department for more than a decade. The country's most prestigious event in Chemical Engineering - Indian Chemical Engineering Congress - CHEMCON-2011 was organized here. The event invited the top chemical engineers of the nation to our Institute. A joint session with Canadian Universities in the area of Energy and Environment was also a part of this event.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs

MISSION OF THE INSTITUTE

MSRIT shall meet the global socio-economic needs through

1. Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization
2. Establishing research clusters in emerging areas in collaboration with globally reputed organizations
3. Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs

QUALITY POLICY

We at M S Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

VISION OF THE DEPARTMENT

To be a leading chemical engineering department for imparting quality technical education and progressive research at global level.

MISSION OF THE DEPARTMENT

1. To provide a state of art environment and a rigorous academic program that train students to excel in fundamental sciences, chemical and allied engineering fields.
2. To offer a programme that inculcates creative thinking and lifelong learning contributing to the advancements in chemical sciences and its application.
3. To foster principles of sustainability and promote environmentally benign technologies for the benefit of society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

The B.E. Chemical Engineering Program at Ramaiah Institute of Technology aims to provide a strong foundation of scientific and technical knowledge in a state of art learning ambience. It equips the graduates with problem solving abilities, teamwork, and communication skills necessary throughout their careers. They are consistent with the following Educational Objectives:

1. To produce graduates with a strong foundation and understanding of the fundamental principles of mathematics, science and engineering enabling graduates to pursue their careers as practicing chemical engineers in Chemical and Allied Engineering fields.
2. To produce graduates who are prepared to pursue their post-graduation and Research in the emerging and allied areas of Chemical Engineering and Business.
3. To produce graduates who possess skills with professional integrity and ethics to assume professional leadership roles and administrative positions.
4. To provide students with opportunities to integrate with multidisciplinary teams to develop and practice written and oral communication skills.

PROGRAM OUTCOMES (POs):

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs):

The Chemical Engineering graduate will be able to

PSO1: Acquire in-depth knowledge of chemical engineering, process economics, management, safety and environmental aspects required to pursue their career in chemical industry and allied engineering areas.

PSO2: Apply computational and simulation tools to solve, design and optimize chemical engineering problems/ processes.

PSO3: Design processes, perform experiments, prepare technical and management modules, economic evaluation and demonstrate professional engineering competence.

Semester wise Credit Breakdown for B.E Degree Curriculum
Batch 2021-25

Semester / Course Category	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Basic Sciences (BSC)	08	08	03	03	--	--	--	--	22
Engineering Sciences (ESC)	11	09	--	--	--	--	--	--	20
Humanities, Social Sciences and Management (HSMC)	--	02	01	01	03	03	--	--	10
Ability Enhancement Course (AEC)	01	01	01	01	01	--	03	--	08
Universal Human Values (UHV)	--	--	02	--	--	--	--	--	02
Professional Core Courses (PCC)	--	--	11	12	11	05	04	--	43
Integrated Professional Core Course (IPCC)	--	--	03	03	03	--	04	--	13
Professional Elective Courses (PEC)	--	--	--	--	03	06	03	--	12
Institutional Open Elective Courses (IOE)	--	--	--	--	--	03	03	--	06
Internship (INT)	--	--	--	02	--	02	--	05	09
Mini Project / Project Work (PW)	--	--	--	--	--	03	03	09	15
Non Credit Mandatory Courses (NCMC)	--	--	Yes	--	Yes	--	--	--	--
Total Credits	20	20	21	22	21	22	20	14	160

SCHEME OF TEACHING V SEMESTER

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total contact hours /week
					L	T	P	Total	
1	**CH51**	**Chemical Reaction Engineering - II**	Chemical Engineering	PCC	2	1	0	3	4
2	**CH52**	**Process Equipment Design**	Chemical Engineering	IPCC	1	1	1	3	5
3	**CH53**	**Chemical Process Industries**	Chemical Engineering	PCC	3	0	0	3	3
4	**CH54**	**Mass Transfer-II**	Chemical Engineering	PCC	2	1	0	3	4
5	**CHE55X**	**Program Elective Course - 1**	Chemical Engineering	PEC	3	0	0	3	3
6	**CHL56**	**Mass Transfer Lab**	Chemical Engineering	PCC	0	0	1	1	2
7	**CHL57**	**Computational Methods Lab**	Chemical Engineering	PCC	0	0	1	1	2
8	**AL58**	**Research Methodology and Intellectual Property Rights**	Chemical Engineering	HSMC	3	0	0	3	3
9	**AEC510**	**Ability Enhancement Course- V**	Any department	AEC	1	0	0	1	1
Total								**21**	**27**
10	**HS59**	**Environmental Studies ***		NCMC	0	0	0	0	1

Program Elective Course- I

CHE551	Material science	CHE554	Interfacial Phenomenon and Surface Engineering
CHE552	Petroleum Refining Technology	CHE555	Polymer Processing Technology
CHE553	Non-conventional energy Resources		

* Environmental Studies is under the category of NCMC, 1 hour of teaching per week has to be allocated in the timetable.

Nomenclature: IPCC: Integrated Professional Core Course**, PCC:** Professional Core Course**, HSMC:** Humanity and Social Science & Management Courses**, PEC:** Professional Elective Courses**, AEC–**Ability Enhancement Courses,
NCMC: Non-credit Mandatory Course

L –Lecture, T – Tutorial, P- Practical/ Drawing

Note: XXE55x, where x=1,2,3,4,5

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with practical of the same course. Credit for IPCC is 03 and its Teaching–Learning hours (L: T : P) can be considered as (2 : 0 : 1). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated only by CIE (no SEE). However, questions from the practical part of IPCC can be included in the SEE question paper.

Professional Elective Courses: A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of five courses. The minimum student's strength for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Innovation/ Societal/ Entrepreneurship based Internship: At the End of fourth Semester four - weeks Summer Internship Shall Be Carried Out – Based On industrial/Govt./NGO/MSME/Rural Internship/Innovation/Entrepreneurship. All the students admitted shall have to undergo mandatory internship of 04 weeks during the vacation of IV semester. A Viva-Voce examination shall be conducted during VI semester and the prescribed credit shall be included in VI semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent examination after satisfying the internship requirements.

AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):

Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years' degree program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8^{th} semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. Incase student fail to earn the prescribed activity points; 8^{th} semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the 8^{th} semester grade card.

The Non-Credit Mandatory Course The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. In case, any student fails to secure the minimum 40% of the prescribed CIE marks, he/she shall be deemed to have secured **'F'** grade. In such a case, the student has to fulfil the requirements during subsequent semester/s to appear for CIE. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.

SCHEME OF TEACHING VI SEMESTER

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total contact hours /week
					L	T	P	Total	
1	**AL61**	**Management & Entrepreneurship**	Chemical Engineering	HSMC	3	0	0	3	3
2	**CH62**	**Process Control**	Chemical Engineering	PCC	2	1	0	3	4
3	**CHE63X**	**Program Elective Course - 2**	Chemical Engineering	PEC	3	0	0	3	3
4	**CHE64X**	**Program Elective Course - 3**	Chemical Engineering	PEC	3	0	0	3	3
5	**CHL65**	**Simulation Lab - I**	Chemical Engineering	PCC	0	0	1	1	2
6	**CHL66**	**Process Control Lab**	Chemical Engineering	PCC	0	0	1	1	2
7	**CHOE01***	**Institutional Open Elective - 1**	Chemical Engineering	IOE	3	0	0	3	3
8	**CHP67**	**Mini Project/Design Project**	Chemical Engineering	PW	0	0	3	3	-
9	**INT68**	**Innovation/Societal/Entrepreneurship Based Internship**	Chemical Engineering	INT	0	0	2	2	-
Total								**22**	**20**

Program Elective Course- 2

CHE631	Pharmaceutical Technology	CHE634	Chemical Process Optimization
CHE632	Biofuels	CHE635	Principles of Food Processing and Preservation
CHE633	Electrochemical Technology		

Program Elective Course- 3

CHE641	Operation research	CHE644	Modelling of Chemical Process
CHE642	Industrial waste water treatment	CHE645	Biochemical Engineering
CHE643	Hazard analysis and risk management		

Nomenclature, PCC: Professional Core Course**, PEC:** Professional Elective Courses, **IOE:** Institutional Open Elective, **PW:** Mini Project, **INT** –Internship

L –Lecture, T – Tutorial, P- Practical/ Drawing/ Project work

Professional Elective Courses: A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of five courses. The minimum student's strength for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Institutional Open Elective Courses:

Students belonging to a particular stream of Engineering and Technology are not entitled for the open electives offered by their parent department. However, they can take an elective offered by other departments, provided they satisfy the prerequisite condition, if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor.

Selection of an open elective shall not be allowed if,

1. The candidate has studied the same course during the previous semesters of the program.
2. The syllabus content of open electives is similar to that of the Departmental core courses or professional electives.
3. A similar course, under any category, is prescribed in the higher semesters of the program.
4. The minimum students' strength for offering open electives is 10. However, this condition shall not be applicable to cases where the admission to the program is less than 10.

Mini-project work: Mini Project is a laboratory-oriented course that will provide a platform for students to enhance their practical knowledge and skills through the development of small systems/applications.

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary mini-project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of

the project report, project presentation skill, and question and answer session as per the rubrics defined by the department.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project.

The CIE marks awarded for the Mini-project shall be based on the evaluation of the project report, project presentation skill, and question and answer session as per the rubrics defined by the parent department.

SEE component for Mini-Project: SEE will be conducted by the two examiners appointed by the Institute. SEE marks awarded for the mini project shall be based on the evaluation of the project work report, project presentation skill, and question and answer session.

Research/Industrial Internship - At the end of the sixth/seventh semester (in two cycles to accommodate all the students) Research/Industrial Internship shall be carried out – Based on Industrial/Govt./NGO/MSME/Rural Internship/Innovation/Entrepreneurship. All the students admitted shall have to undergo a mandatory internship of 24 weeks during the vacation of VI/VII semesters. A Viva-Voce examination shall be conducted during the VII semester and the prescribed credit shall be included in VII semesters. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during the subsequent examination after satisfying the internship requirements.

Research internship Students have to take up research internships at Centres of Excellence (CoE) established in the same institute and /or out of the institute at reputed research organizations / Institutes. A research internship is basically intended to give you the flavour of current research going on in a particular topic/s. The internships serve this purpose. They help students get familiarized with the field, the skill needed the effort amount and kind of effort required for carrying out research in that field.

Industry internships: Is an extended period of work experience undertaken by /Institute students looking to supplement their degree with professional development. The students are allowed to prepare themselves for the workplace and develop practical skills as well as academic ones. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with "unexpected contingencies" helps students recognize, appreciate, and adapt to organizational realities by tempering knowledge with practical constraints.

AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):

Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years' degree program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8^{th} semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. Incase student fail to earn the prescribed activity points; 8^{th} semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the 8^{th} semester grade card.

Semester V

CHEMICAL REACTION ENGINEERING II	
Subject Code: CH51	**Credits: 2:1:0**
Pre requisites: Chemical Reaction Engineering-II	**Contact Hours: 42L+14T**
Course Coordinator: Dr. V. Sravanthi	

Course content

Unit I

Fluid-particle reactions: kinetics- selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling. Fluid –particle reactor design for non-catalytic heterogeneous reactions

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/103/106/103106117/

Unit II

Introduction to catalysis: Steps in a catalytic reaction, Adsorption on solid surfaces (Langmuir and Freundlich isotherm), Classification and Preparation of catalyst, Surface area estimation by BET, Promoters, inhibitors and accelerators. Methods of Catalyst characterisation (XRD, FTIR).

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/103/103/103103026/

Unit III

Mechanism of catalysis, Rate controlling steps and their derivation for finding rates for A+B⇄C and A+B⇄C+D.

Deactivating catalysts- Types of deactivation, mechanisms of catalyst deactivation, Batch solids: rate and performance equations for independent deactivation.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/103/106/103106117/
  https://enine.digimat.in/nptel/courses/video/103101001/L11.html

Unit IV

Solid catalysed reactions: Spectrum of kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Porous catalyst

particles. Heat effects during reaction. Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/103/103/103103026/

Unit V

Packed bed catalytic reactor and reactors with suspended solid catalyst. Fluidized reactors of various type. Qualitative design of fluidized bed reactor. Kinetics of trickle bed and slurry reactors.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/103/106/103106117/

Text Books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons.
2. Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill.

Reference Books:

1. Fogler, H.S., Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall.
2. Carberry, J.J., Chemical & Catalytic Reaction Engineering, McGraw Hill.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the kinetics of heterogeneous reaction system and design a reactor for non-catalytic reaction. (PO-1,2,3,4, PSO-1,2)
2. Prepare the catalysts of required properties and can evaluate its performance. (PO-1,2,3,4, PSO-1,2)
3. Develop the mechanism and determine the deactivation rate of catalytic reactions. (PO-1,2,3,4, PSO-1,2)
4. Determine the effectiveness of catalyst and calculate rate experimentally. (PO-1,2,3,4, PSO-1,2)
5. Explain and design various types of reactors. (PO-1,2,3,4, PSO-1,2)

PROCESS EQUIPMENT DESIGN	
Subject Code: CH52	**Credits: 1:1:1**
Pre requisites: Chemical Process Calculations Process Heat Transfer, Mass Transfer-I and II	**Contact Hours: 14L+14T+14P**
Course Coordinator: Dr. D Jaya Prasanna Kumar	

Course content

Detailed chemical engineering process and mechanical design of the equipment: Pressure vessel - Jacketed vessel, Double pipe Heat exchanger, Shell & Tube Heat exchanger, Condensers – Horizontal and vertical, Evaporator – Single effect, Distillation Column, Packed Bed Absorption Column, Rotary Dryer. Mechanical design.

Standard Code books to be used. The detailed dimensional drawings shall include sectional front view, Full Top/side view depending on equipment and major component drawing with dimensioning using AutoCAD software.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://nptel.ac.in/courses/103107207
  http://a.impartus.com/ilc/#/course/2583945/1205
- **Laboratory:** Drawing of Double Pipe Heat Exchanger, Shell and tube heat exchanger, Evaporator, Distillation column, and packed bed column using AutoCAD

Reference Books:

1. Joshi, M.V., Process Equipment Design, Macmillan India, 1991.
2. Brownell, L.E. and Young, E.H., Process Equipment Design - Vessel Design, John Wiley and Sons, Inc.1959.
3. Ludwig, E.E., Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2, 3rd Ed., Gulf Publishing Co. 1997.
4. Indian Standards Institution, Code for Unfired Pressure Vessels, IS – 2825.
5. Bhattacharya, B.C, Introduction to Chemical Equipment Design, CBS Publications, 1985.
6. Perry's Chemical Engineers Handbook.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Design Heat Transfer Equipment's as per standard procedure. (PO- 2, 3, PSO-1, 2)
2. Design Mass Transfer Equipment's. (PO- 2, 3, PSO-1, 2)
3. Design pressure vessels and other equipment's with reference to IS Standards. (PO- 2, 3, PSO-1, 2)

CHEMICAL PROCESS INDUSTRIES	
Subject Code: CH53	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Dr. Ashwini Wali	

Course content

Unit I

Sulfur: Elemental Sulfur mining, Sulfur from ores, Oxides of Sulfur (SO_2, SO_3).
Industrial Gases: CO_2, H_2, O_2, N_2, Water gas.
Acids: Sulfuric, Nitric, Hydrochloric, phosphoric acid.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/103107082

Unit II

Chlor-Alkali Industries: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder.
Fertilizers: Ammonia, Urea, Ammonium chloride, Ammonium nitrate, Ammonium phosphate, Ammonium sulfate, DAP, Bio fertilizers.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/103107082

Unit III

Phosphorous Industries: Manufacture of white and Red Phosphorus, Pentoxide, Phosphatic Fertilizers, Super Phosphate and Triple Super Phosphate.
Fermentation Industries: Production of alcohol, acetic acid and citric, penicillin.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/106/103106109/

Unit IV

Petroleum Industries: Constituents of crude petroleum refining, catalytic cracking, processing and reforming. Production of Ethylene, Propylene.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/107/103107081/

Unit V

Polymers and Rubber: Polymerization, PVC, LDPE, Polypropylene, cross linked polymers, natural rubber, synthetic rubber and rubber compounding.

Miscellaneous Industries: Paints, Pigments, Vanishes, Enamel, Lacquers - White Lead and Zinc oxide, manufacture of Portland cement, slag cement.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/107/103107081/

Text Books:

1. Shreve's, Chemical Process Industries, McGraw Hill, 4th Edition.
2. Rao Gopal & Sittig Marshall, Dryden – Outlines of Chemical Technology for 21st Century, 3rd Edition, and EWP.

Reference Book:

1. Bose, P.K., Chemical Engineering Technology, Vol. 1, 2, Books and Allied (Pvt) Ltd, 2011.
2. Desikan and Sivakumar, Unit Processes in Organic Chemical Industries (Eds.), CEDC, IITM, 1982.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Develop flow chart which includes various unit processes and unit operations for sulfur based chemicals, industrial gases and acids. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
2. Write manufacturing process based on reactions, operations involved in the production of chlor-alkali chemicals and fertilizer industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
3. Explain and develop the material requirements, flow diagrams in the manufacturing of phosphorous based chemicals and fermentation industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
4. Design based on the knowledge of processing of crude petroleum and petro chemicals. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
5. Develop flow chart and explain the production of polymer based chemicals, rubber and miscellaneous industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1).

MASS TRANSFER-II	
Subject Code: CH54	**Credits: 2:1:0**
Pre requisites: Mass Transfer-II	**Contact Hours: 28L+14T**
Course Coordinator: Dr. Brijesh	

Course content

Unit I

Absorption: Absorption. Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors. Construction details. HETP and HTU concepts. Liquid phase hold up and pressure drop in absorption towers. Operating line and minimum solvent flow rates. Design of packed towers (height and diameter). Multi-component absorption. Absorption with chemical reaction.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/104/103104046/
- Impartus recording: https://a.impartus.com/ilc/#/course/96146/452

Unit II

Distillation: Introduction. Vapour liquid equilibrium (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Steam distillation. Flash and simple distillation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/104/103104046/
- Impartus recording: https://a.impartus.com/ilc/#/course/96146/452

Unit III

Multistage distillation. Multi-stage rectification column. Design using McCabe-Thiele method for binary mixtures. Ponchon-Savarit method. Efficiencies–overall, local, and Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and Azeotropic distillations.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/104/103104046/
- Impartus recording: https://a.impartus.com/ilc/#/course/96146/452

Unit IV

Extraction – Liquid-Liquid Extraction: Ternary equilibrium. Solvent selection. Single stage. Multistage-cross-current, counter-current extraction. Equipment for liquid-liquid extraction.

Solid-Liquid Extraction: Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. Calculation of single stage and multi-stage leaching operation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/103/103103154/
- Impartus recording: https://a.impartus.com/ilc/#/course/96146/452

Unit V

Membrane Separations: Membranes. Membrane modules. Concentration Polarisation and Fouling. Classification of Membrane Separation Processes. Microfiltration. Ultrafiltration, Reverse Osmosis, Dialysis, Gas Permeation, Electro dialysis, Pervaporation, Nano filtration.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/103/103103154/
- Impartus recording: https://a.impartus.com/ilc/#/course/96146/452

Text Books:

1. Dutta, B.K., Mass Transfer Principles and Separation Processes, 1st Edition, PHI, 2006.
2. Narayanan, K.V., Laksmikutty, B., Mass Transfer - Theory and Practice, 1st Edition, CBS, 2014.

Reference Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Foust, A., Principals of Unit Operation, 2nd Edition, John Wiley, 1994.
3. Geankoplis, C. J, Transport Processes and Unit Operation, Prentice Hall (I), 2000.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain absorption, desorption operations and design equipment's for carrying out such operations. (PO- 1, 2, 3 PSO-1)
2. Explain vapour-liquid equilibrium and single stage and batch operation using the principles. (PO- 1, 2, 3, PSO-1)

3. Design equipment for continuous rectification. (PO- 1, 2, 3, 12, PSO-1)
4. Explain liquid-liquid and solid-liquid extraction and select/design for carrying out such operations. (PO- 1, 2, 3, 12, PSO-1)
5. Select and design equipment's for membrane separation operations. (PO- 1, 2, 3, 12, PSO-1).

MATERIAL SCIENCE	
Subject Code: CH551	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Introduction: Introduction to Materials Science, Classification of Engineering Materials, Levels of Structure, Structure-Property relationship in materials, Primary and secondary bonds.

Crystal Geometry and Structure Determination: Geometry of crystals- the Bravais lattices, Crystal directions and Planes- Miller indices, Structure determination-X – ray diffraction- Braggs Law, the power method.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/113/102/113102080/

Unit II

Crystal Imperfections: Point Imperfections, Line imperfections- edge and screw dislocations, Surface imperfections.

Phase Diagram And Phase Transformations: Phase rule, Single component systems, Binary Phase Diagrams, Lever rule, Typical Phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron-carbon system, Nucleation and growth, Solidification, Allotropic transformation, Cooling curves for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT curves).

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/113/102/113102080/

Unit III

Deformation of Materials: Metals - Elastic deformation, Plastic deformation, Dislocation and Strengthening mechanism, Failure – Fracture, Fatigue.

Ceramics- Brittle fracture, Stress-Strain behavior, Plastic deformation

Polymers - Visco-elastic deformation, Fracture, Elastomer deformation.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/113/104/113104104/

Unit IV

Materials Processing: Metals and Alloys – Fabrications – Forming, Casting.
Thermal Processing: Annealing, Heat treatment of Steels. Surface hardening methods.
Ceramics – Fabrication and processing of glass
Polymers – Polymerization, Additives, Forming methods, Fabrication of elastomers and fibres.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/113/104/113104104/

Unit V

Corrosion And its Prevention: Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, Corrosion rate and its prediction, Prevention of corrosion. Corrosion charts.
Materials Selection and Design Considerations**,** Environmental considerations and recycling.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/113/104/113104104/

Text Books:

1. William D. Callister ,Materials Science and Engineering: An Introduction, 6th Edition, Wiley, 2006.
2. Hajra Choudhary S. K., Material Science and Processes, Indian Book Distributing Co., 1982.

Reference Books:

1. Van Vlack, H.L., Elements of Materials Science, 2nd Edition, Addision-Wesly Publishing Company, NY, 1964.
2. Raghavan V., Material Science and Engineering- A First Course, 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 1996.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Classify different types of engineering materials depending on structure property, crystal geometry and X-Ray diffraction. (PO-1,2,3, PSO-1)
2. Draw phase diagrams of different metals, TTT curves and explain crystal imperfections. (PO-2,3, PSO-1)
3. Explain mechanism of deformation of materials. (PO-3,5,7, PSO-1)
4. Suggest different type fabrication methods for materials. (PO-6,7,PSO-1)
5. Select materials depending on type of application. (PO-6 PSO-1)

PETROLEUM REFINING TECHNOLOGY	
Subject Code: CH552	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Dr. D Jaya Prasanna Kumar	

Course content

Unit I

Indian Petroleum Industry: Prospects & Future. Major companies. World production, Markets, Offshore and Onshore, Oil well technology.

Composition of crude: Classification. Evaluation of petroleum. UOP-k factor, TBP analysis, EFV analysis. Average boiling point. ASTM curves.

Thermal properties of petroleum fractions.

Product Properties, Test and Storage methods: Gas - Various types of gas and LPG. Reid vapours pressure analysis.

Gasoline and Naphtha - Octane Number. Oxidation stability. Gasoline additives

Kerosene /ATF - Characterization for flash point or fire point, volatility, burning qualities etc.

Diesel –Cetane number, viscosity etc. Grades of diesels and additives.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/102/103102022/
  https://onlinecourses.nptel.ac.in/noc23_ch64/preview

Unit II

Crude Pre-treatment: Pumping of crude oils. Dehydration of crude by chemical, gravity, centrifugal, electrical de-Salter and comparison of each.

Heating of crude - heater, types of fired heaters including box and cylindrical type etc.

Crude distillation - Design aspects for atmospheric and vacuum column. Atmospheric and Vacuum distillation unit: internals and operational. Types of reflux.

Catalytic reforming, Isomerisation and Alkylation: Theory of reforming, factors influencing reforming, reforming catalysts, feedstock requirements. Platforming. Isomerisation and Alkylation

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/102/103102022/
  https://onlinecourses.nptel.ac.in/noc23_ch64/preview

Unit III

Catalytic cracking processes and Catalytic conversion processes: Fluid catalytic cracking with special reference to catalyst and reactor design configurations, Resid FCC

Hydro processing

Hydrocracking: Theory of hydro cracking**,** catalyst and reactor design configurations.

Hydro treating and hydrodesulphurization processes: catalyst, reactor design configuration

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/102/103102022/
  https://onlinecourses.nptel.ac.in/noc23_ch64/preview

Unit IV

Treatment of kerosene - De-aromatisation, desulphurisation by hydrogen and catalysts.

Treatment of Diesel, Naphtha: desulphurisation by hydrogen and catalysts

Hydrogen production, purification and management.

Thermal Cracking and Thermal conversion processes: Thermal cracking reactions - theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials.

Visbreaking – Process Description and operating variables.

Coking - delayed coking, fluid coking, and flexi coking.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/102/103102022/
  https://onlinecourses.nptel.ac.in/noc23_ch64/preview

Unit V

Bottoms of Barrel Process/ Residue Upgrading - IMO MARPOL requirement.

Gas treating, Sulphur Recovery Process and Sour Water Strippers –

Mercaptans Removal – Kerosene Merox and other Merox processes.

Blending – Types, Linear Programming for blending

Refinery Economics – Refinery Margins and complexity**.**

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/102/103102022/
  https://onlinecourses.nptel.ac.in/noc23_ch64/preview

Text Books:

1. Nelson, Petroleum Refinery Engineering, 4th Edition, McGraw Hill, 1964.
2. Bhaskara Rao, Modern Petroleum Refining Processes, 3rd Edition, Oxford and IBH, 1997.

Reference Books:

1. Desikan and Sivakumar, Unit Processes in Organic Chemical Industries (Eds.), CEDC, IITM, 1982.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Classify the crude and understand the composition. (PO-1, 2, 3, PSO-1, 2)
2. Explain crude pretreatment methods and operations involved in it. (PO-1, 3, PSO- 2)
3. Explain various impurities present in the crude and methods for their treatment to produce useful products like LPG, LNG, Gasoline, lube etc (PO-2, 3, 4 PSO-1, 2)
4. Explain various petroleum cracking processes. (PO-2, PSO- 2)
5. Explain crude processing methods. (PO-1, 3, PSO- 1)

NON-CONVENTIONAL ENERGY SOURCES AND TECHNOLOGY	
Subject Code: CH553	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Dr. V Sravanthi	

Course content

Unit I

Introduction to conventional & non-conventional energy sources: Solar Energy: Solar radiation measurement – solar constant, solar radiation at earth's surface, solar radiation geometry, solar radiation measurement. Solar energy. Applications – solar water heating, space heating, space cooling, solar thermal electric conversion. Agriculture and industrial process heating, solar distillation, solar pumping, solar cooking.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/121/106/121106014/
  https://archive.nptel.ac.in/courses/103/103/103103206/
  https://www.youtube.com/watch?v=gx_bt63lTxw

Unit II

Energy from biomass (bio – energy): Introduction. Biomass conversion Technologies. Wet processes. Dry processes. Biogas generation. Factors affecting bio digestion or generation of gas. Classification of biogas plants. Advantages and disadvantages of floating drum plant. Advantages and disadvantages of fixed dome type plant. Types of biogas plants (KVIC model & Janata model). Selection of site for biogas plant.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/103/103103206/

Unit III

Bio – Energy (Thermal Conversion): Methods of obtaining energy from biomass. Thermal gasification of biomass. Classification of biomass gasifiers. Chemistry of gasification process. Applications of the gasifiers.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/103/103103206/

Unit IV

Wind Energy: Introduction. Basic components of WECS (wind energy conversion system). Classification of WECS. Types of wind machines- horizontal axis machines, vertical axis machines. Applications of wind energy.

Energy from the oceans: Introduction. Ocean thermal electric conversion (OTEC). Methods of ocean thermal electric power generation. Open cycle OTEC system. Closed or Anderson OTEC cycle, hybrid cycle. Application of energy from oceans.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/103/103103206/
  https://www.youtube.com/watch?v=DD0Y6Snxpdk

Unit V

Fuel Cells Basics: Fuel Cells, Difference between batteries and fuel cells. Components of fuel cells. Principle of working of fuel cells. Application of fuel cells. Performance characteristics and efficiency of fuel cells, Fuel cell stack, Fuel cell power plant, Fuel cell types.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/121/106/121106014/

Text Books:

1. Rai, G.D., Non-Conventional Energy Sources, Khanna Publications, 1st Edition, Second Reprint, 2010.
2. Sukhatme, S.P., Solar Energy, Third Edition, 1st Reprint, Tata McGraw Hill, New Delhi, 2008.

Reference Books:

1. Jain, P.C., Jain, M., Engineering Chemistry, Dhanpat Rai & Sons, 10th Edition, 3rd Reprint, 1995.
2. Rai, G.D., Solar Energy Utilization, 4th Edition, Khanna Publications.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Compare different types of fuels and elucidate the application of solar energy. (PO-1, 7, PSO-1)
2. Understand biomass conversion technologies and types of biogas plants. (PO-1, 3, 7, PSO-1)
3. Understand thermal gasification of biomass and chemistry of gasification. (PO-1, 7, PSO-1)
4. Explain technologies of Wind energy and ocean. (PO-1, 7, PSO-1)
5. Apply latest technology like fuel cell. (PO-1, 3, 7, PSO-1)

INTERFACIAL PHENOMENA AND SURFACE ENGINEERING	
Subject Code: CH554	**Credits: 3:0:0**
Pre requisites: Chemical Engineering Thermodynamics	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Introduction: Concept of Interface and its formation with examples. Mechanical and Thermodynamic approaches to Interface. Equivalence in the concepts of surface energy and surface tension. Applications.

Excess Pressure: Generalized equation for excess pressure across a curved surface- the equation of Young and Laplace. Pressure jump across cylindrical surface, flat surface. Vapour pressure of a drop Solubility of drops. Ostwald ripening. Capillary condensation. Super saturation. Nucleation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/102/103102016/

Unit II

Measurement of Interfacial tension: Capillary rise method. Drop weight method, Wilhemy plate method, du nuoy method. Methods based on shape of static drops or bubbles. Dynamic Methods-Flow and capillary waves.

Thermodynamics of Interfaces: Thermodynamic treatment of interfaces. Free energy at interface. Temperature dependence of the surface tension. Effect of pressure on interfacial tension. Effect of curvature on surface tension. Thermodynamics of binary Systems-Gibbs Equation. Surface excess concept. Verification of Gibbs equation. Gibbs monolayers.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/102/103102016/

Unit III

Wetting fundamentals and contact angles: Work of adhesion, cohesion. Criteria for spreading of liquids. Kinetics of spreading. Lens formation- three phase systems. Young's equation. Neumann triangle. Theories of equilibrium contact angles. Contact angle hysteresis.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/102/103102016/

Unit IV

Electrical aspects of surfaces: The electrical double layer. Stern treatment of electrical double layer. Free energy of a diffused double layer. Repulsion between two plane double layers. Colloidal dispersions. Combined attractive and electrical interaction-DLVO theory. Kinetics of coagulation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/102/103102016/

Unit V

Surfactants: Anionic and non-ionic. Other phases involving surfactant aggregates. Surface films of insoluble surfactants. Thermodynamics of micro emulsions. Phase behaviour of oil-water-surfactant systems. Effect of composition changes. Applications of surfactants-emulsions and detergency.

Introduction to interfaces in motion: Linear analysis of interfacial stability. Damping of capillary wave motion by insoluble surfactants. Stability and wave motion of thin liquid films-foams. Interfacial stability for fluids in motion.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/102/103102016/

Text Books:

1. Miller, C.A. &Niyogi, P., Interfacial Phenomena, Equilibrium and Dynamic Effects, Marshel Deckder, 1985.
2. Adamson, A.W., Physical Chemistry of Surfaces, John Wiley, 5th Edition, 1981.

Reference Books:

1. Millet, J.L., Surface Activity, 2nd Edition, Van Nostrad, 1961.
2. Gorrett, H.E., Surface Active Chemicals, Pergemon Press, 1974.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain mechanical and thermodynamic approaches to interface and Derive the equation for excess pressure across different surfaces. (PO-1, PSO-1)
2. Explain different methods of interfacial tension measurement. (PO-1, PSO-1)
3. Explain concepts of kinetics of spreading, contact angle hysteresis. (PO-1, 2, 12, PSO-1)
4. Explain electrical aspects of surfaces. (PO-1, 2, 12, PSO-1)
5. Explain thermodynamic and mass transfer considerations of surfactants. (PO-1, 2, 12, PSO-1)

POLYMER PROCESSING TECHNOLOGY	
Subject Code: CH555	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Principles of processing of polymers: Melt processing of thermoplastics. Classification of processes. Thermoset plasting processing, crystallization, orientation & shrinkage, co polymers blending, compounding for engineering application, stress – strain behaviour, WLF equation, practical assessment for long term behaviour.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ch67/preview

Unit II

Polymer extrusion: Requirements of Polymer for extrusion. Single screw and double screw plasticising extruder zones in extrusion, breaker plates, extruder screw, power calculation. PVC extruder. Die and calibration equipment prime mover for extrusion, co extrusion, extrusion coating, extrusion film blowing reactive extrusion. Extrusion blow moulding for PET bottles, wire drawing-PVC, spinning – various types and applications. Application of various extruded products. Rheological aspects of extrusion and extrusion defects. Operational and maintenance of extrusion equipment.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ch67/preview

Unit III

Injection moulding: Polymer characteristics for injection moulding. Reciprocating screw injection moulding. Single impression mould. Multi impression moulds. Cooling requirements in moulds. Hot runner moulds, gate, mould clamping force calculations. Control of pressure, temperature and time of injection thermostat and fibre reinforced polymer injection moulding, sandwich moulding and injection blow moulding. Rheological aspects and defects of injection. Comparison of injection moulding and extrusion of injection. Operational and maintenance of injection moulding equipment's. Reaction injection moulding. Applications.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ch67/preview

Unit IV

Compression moulding: Applications. Principles. Comparison with other processing methods. Derivation of compression mould thickness or compaction force. Transfer moulding.

Calendaring: Characteristics of polymer for calendaring. Principles and operation of calendaring. Derivation of film thickness and pressure required for rollers. Gauge control during calendaring. Application of PVC calendared products.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ch67/preview

Unit V

Thermoforming: Basic principles. Vacuum forming. Pressure forming. Description of operations. Product design. Application. Derivation of thermoformed product thickness.

Rotational moulding: Principles. Operation & applications. Thickness. Cooling calculations.

Testing of plastics: Thermal, electrical, optical, mechanical properties testing.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ch67/preview

Text Books:

1. Johnes, M., Principles of Polymer Processing, Chapman and Hall, 1989.
2. Crawford, R.J., Plastic Engineering, 3rd Edition, Butterworth-Hienemann, 1998.

Reference Books:

1. McCrum, N.G., Buckley, C.P., Principles of Polymer Engineering, Oxford Press, 1988.
2. Manas Chandha, Polymer Materials –Vol 1,2 & 3, Springer.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Assess and use equipment's and choose a suitable polymer for specific fabrication. (PO-1, 2, 3, PSO-1)
2. Understand a product design, production rate and choose an appropriate shaping operation. (PO-1, 2, 3, PSO-1)
3. Test the manufactured product for suitability. (PO-1, 2, PSO-1)
4. Make modifications to moulds and dies for product development. (PO-1, 2, 3, PSO-1)
5. Suggest packaging solutions. (PO-1, 2, 3, PSO-1)

MASS TRANSFER LABORATORY	
Subject Code: CHL56	**Credits: 0:0:1**
Pre requisites: Mass Transfer	**Contact Hours: 14P**
Course Coordinator: Dr. Rajeswari M Kulkarni	

Course content

List of experiments suggested:

1. Diffusion of organic vapour in air
2. Simple Distillation
3. Packed column/ plate column distillation
4. Steam distillation
5. Solid – liquid leaching
6. Surface evaporation
7. Tray dryer
8. Adsorption studies
9. Liquid - Liquid /Vapour –Liquid equilibrium
10. Liquid extraction – (cross current: 1 and 2 or 3 stage)
11. Hold up studies in packed columns
12. Rotary/ vacuum dryers
13. Wetted wall column
14. Cooling tower
15. Solid dissolution

Course Outcome (COs):

The student will be able to

1. Understand the working principles of mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)
2. Evaluate the performance of mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)
3. Select and design mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)

COMPUTATIONAL METHODS LAB	
Subject Code: CHL57	**Credits: 0:0:1**
Pre requisites: Engineering Mathematics IV Fundamentals of Computing	**Contact Hours: 14P**
Course Coordinator: Dr. Brijesh	

Course content

List of programmes: (C, MS Excel and MATLAB):

1. MATLAB – Matrices/ Polynomials/ Integral/ Differential/ Plots
2. Data handling and regression using MS-Excel
3. Non-linear algebraic equation
4. Problems on general material balance
5. Numerical Integration- Simpson's 1/3 Rule
6. Ordinary Differential Equation- R-K Method
7. Curve Fitting-Least Square
8. Calculation of Bubble Point and Dew Point for Ideal multi-component system
9. P-x,y and T-x,y data generation from the given vapor pressure data
10. Flash Vaporization for multi-component system
11. Design of Batch Reactor/ PFR/ CSTR
12. Double pipe heat exchanger (Area, Length and Pressure drop)

Course Outcome (COs):

On successful completion of the course students will be able to

1. Analyze chemical engineering problems by using numerical methods. (PO- 1, 2, 3, 4, 5, PSO-2)
2. Write programs in C/ MS Excel for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2)
3. Write programs in MATLAB for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2)

RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	
Subject Code: AL58	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Sri. Sagar J S	

Course Content

Unit I

Research Methodology

Introduction: Meaning of Research, Objectives of Research, Types of Research, Ethics in Research, Types of Research Misconduct.

Literature Review and Technical Reading, New and Existing Knowledge, Analysis and Synthesis of Prior Art, Bibliographic Databases, Conceptualizing Research, Critical and Creative Reading.

Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge flow through Citations, Acknowledgments, and Attributions.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc22_ge08/preview

Unit II

Research Design: Need for Research Design, Important Concepts Related to Research Design: Dependent and Independent Variables, Extraneous Variable, Variable, Common Control, Confounded Relationship, Research Hypothesis, Experimental and Control Groups, Treatments.

Experimental Designs: Introduction to Randomised Block Design, Complete Randomised Design, Latin Square Design, and Factorial Design.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc22_ge08/preview

Unit III

Method of Data Collection: Primary and Secondary Data Collection.

Sampling Design: Sampling fundamentals, Measurement, and Scaling Techniques, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, and Types of Sample Design.

Data Analysis: Testing of Hypotheses: Null Hypothesis, Alternative Hypothesis, Type I and Type II Errors, Level of Significance. Procedure for Hypothesis Testing:

Mean, Variance, Proportions. Chi-square Test, Analysis of Variance (One Way ANOVA), and Covariance (ANOCOVA)

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ge36/preview

Unit IV

Intellectual Property Rights

Introduction to IPR: Different forms of IPR, Role of IPR in Research and Development. TRIPS Agreement, Patent Cooperation Treaty (PCT).

Patents: Brief history of Patents-Indian and Global Scenario, Principles Underlying Patent Law, Types of Patent Applications in India, Procedure for Obtaining a Patent. Non Patentable Inventions. Rights Conferred to a Patentee, Basmati Rice Patent Case.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Unit V

Design: What is a Design? Essential Requirements for a Registrable Design, Procedure of Registration of a Design,

Trademarks: Essentials of a Trademark, Registration, and Protection of Trademarks, Rights Conferred by Registration of Trademarks, Infringements, Types of Reliefs, Case Studies.

Copyrights: Characteristics of Copyrights, Rights Conferred by Registration of Copyrights, Registration of Copyrights, Infringements, Remedies against Infringement of Copyrights, Case studies

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Text Books:

1. C. R Kothari, Gourav Garg, Research Methodology – Methods and Techniques. New Age International Publishers.
2. B L Wadehra – Law relating to Intellectual property. Universal Law Publishing Co.
3. Dipankar Deb, Rajeeb Dey, Valentina E. Balas "Engineering Research Methodology", ISSN 1868-4394 ISSN 1868-4408 (electronic), Intelligent Systems Reference Library, ISBN 978-981-13-2946-3 ISBN 978-981-13-2947-0 (eBook), https://doi.org/10.1007/978-981-13-2947-0.

Reference Books:

1. David V. Thiel “Research Methods for Engineers” Cambridge University Press, 978-1-107-03488-4

Course Outcomes (COs):

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

1. Possess the knowledge of research and conduct a literature review. (PO-8, PO-10, PO-12)
2. Apply the knowledge of research design and design of experiments. (PO-4, PO-8, PO 10, PO-12)
3. Analyse data collection methods, analysis, and sampling design. (PO-4, PO-8, PO-10, PO-12)
4. Understand the global and Indian scenarios of patents and patent applications. (PO-8, PO-10, PO-12)
5. Acquire the requirements of registration and infringements related to trademarks, copyrights, and designs. (PO-8, PO-10, PO-12)

ABILITY ENHANCEMENT COURSE – V	
Subject Code: AEC510	**Credits: 1:0:0**
Pre requisites: Nil	**Contact Hours: 14L**
Course Coordinator: Any Department	

Ability Enhancement Courses (AEC) are the generic skill courses which are basic and needed by all to pursue any career. These courses are designed to help students enhance their skills in communication, language, and personality development. They also promote a deeper understanding of subjects like social sciences and ethics, culture and human behaviour, human rights and the law.

Every student shall register for AEC course under the supervision of his/her proctor. For III, IV & V semester, the student shall select the Ability Enhancement Course online such that the selected course does not overlap with any professional core/ elective course offered by the parent department of the student. After selection, the registration of the course has to be done by the student at his/her parent department.

ENVIRONMENTAL STUDIES	
Subject Code: HS59	**Credits: 0:0:0**
Pre requisites:	**Contact Hours: 14L**
Course Coordinator: Dr. Ashwini Wali	

Course Content

Unit I

Environment, Ecology and Biodiversity

Definition, scope, and importance. Multidisciplinary nature of Environmental studies. Food chain and food web. Energy flow and material cycling in the ecosystem. Biodiversity and threats to biodiversity. Concept of sustainable development: Definition, objectives, and applications.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint presentations, Videos, Models
- Link: https://youtu.be/I_bnGkviWOU
  https://youtu.be/Ar04qG1P8Es

Unit II

Natural resources

Forest resources: Ecological importance of forests. Water resources: Global water resources distribution. Mineral resources: Environmental effects of extracting and processing Mineral resources. Food resources: Effects of modern agriculture. Land resources: Soil erosion and Desertification.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint presentations, Videos
- Link: https://youtu.be/vsXv3anIBSU
  https://youtu.be/1rOVPqaUyv8

Unit III

Energy sources

Growing energy needs. Conventional and non-conventional / Renewable and Non-renewable energy sources. Bio Energy-Ethanol and Bio mass energy. Energy of the future – Hydrogen fuel cells and Nuclear energy. Environmental Impact Assessment (EIA): Definition, Objectives and benefits. Step by step procedure of conducting EIA.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint presentations, Animations, Models
- Link: https://youtu.be/mh51mAUexK4
  https://youtu.be/XS-eXqppf_w

Unit IV

Environmental pollution

Definition, Causes, Effects and control measures of Water pollution, Air pollution and Soil/ land pollution. Management of Municipal Solid Waste and treatment methods of municipal solid waste.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint presentations, Videos
- Link: https://youtu.be/NroFvz8Ugeo
  https://youtu.be/DAQapF-F4Vw

Unit V

Environmental protection

Global warming and Climate change, Acid rain, Ozone layer depletion. Salient features of Environmental Protection Act, Air & Water Acts. Functions of Central and State Pollution Control Boards.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint presentations, Videos, Open source softwares
- Link: https://youtu.be/iV-BvYwl4Y8
  https://youtu.be/BYqLRGawoH0

Text Books:

1. S M Prakash – Environmental Studies, Elite Publishers, 2007.

Reference Books:

1. P. Venugopala Rao – Principles of Environmental Science & Engineering Prentice Hall of India, 1st edition, 2006.

Web links and video Lectures (e- Resources):

1. https://youtu.be/I_bnGkviWOU
2. https://youtu.be/vsXv3anIBSU
3. https://youtu.be/mh51mAUexK4
4. https://youtu.be/NroFvz8Ugeo
5. https://youtu.be/iV-BvYwl4Y8

Course Outcomes (COs):

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

1. Describe the importance of environmental studies, sustainable development and biodiversity (PO-1, 7)
2. Explain the importance and conservation of impacts of natural resources (PO-1, 7)
3. Distinguish the energy sources and identify the alternative energy sources for sustainable development (PO-1, 7)
4. Identify the causes, effects and control measures of pollution in developmental activities (PO-1, 7)
5. Outline the current environmental issues and the role of the agencies for environmental protection (PO-1, 7)

VI Semester

MANAGEMENT & ENTREPRENEURSHIP	
Subject Code: AL61	**Credits: 3:0:0**
Pre requisites: Management & Entrepreneurship	**Contact Hours: 42L**
Course Coordinator: Dr. M Rajesh/Dr. Siddhartha kar	

Course Content

Unit I

Introduction to Management: Definition of Management, Its nature and purpose, Contributions of F.W. Taylor and Henry Fayol to management theory, Functions of managers.

Planning: Types of plans, Steps in planning, the planning process, Management By Objectives (MBO)

Organizing: The nature and purpose of organizing, Formal and informal organization. Organization levels and Span of management, Principle of span of management, the structure and process of organizing

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_mg33/preview
  https://www.digimat.in/nptel/courses/video/110107150/L01.html

Unit II

Staffing: Situational factors affecting staffing.

Leading: Human factors in managing, definition of leadership, Ingredients of leadership

Controlling: Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective controls.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/110107150

Unit III

Introduction to Entrepreneurship: The Foundations of Entrepreneurship: What is an Entrepreneurship?, The benefits of Entrepreneurship, The potential drawbacks of Entrepreneurship; Inside the Entrepreneurial Mind: From Ideas to Reality: Creativity, Innovation and Entrepreneurship, Creative Thinking, Barriers to Creativity

- Pedagogy: Chalk board, power point presentations
- Links:https://www.youtube.com/watch?v=Hgj_kRrvbhQ&list=PL7oBzLzHZ1wXW3mtolxV5nIGn48NLKwrb

Unit IV

The Entrepreneurial Journey: Crafting a Business Plan: The benefits of creating a business plan, The elements of a business plan; Forms of Business Ownership and Buying an Existing Business: Sole proprietorships and partnership.

- Pedagogy: Chalk board, power point presentations
- Links:https://www.youtube.com/watch?v=Tzzfd6168jk&list=PLyqSpQzTE6M8EGZbmNUuUM7Vh2GkdbB1R

Unit V

Launching the Business: Franchising and the Entrepreneur: Types of Franchising, The benefits of buying a Franchise; E-Commerce and the Entrepreneur: Factors to consider before launching into E-commerce, Ten Myths of E-Commerce.

- Pedagogy: Chalk board, power point presentations
- Links:https://www.youtube.com/watch?v=5RMqxtMwejM&list=PLyqSpQzTE6M9zMKj_PSm81k9U8NjaVJkR

Text Books:

1. Harold Koontz, H. Weihrich, and A.R. Aryasri, Principles of Management, Tata McGraw-Hill, New Delhi, 2004.
2. Essentials of Entrepreneurship and Small Business Management – Norman Scarborough & Jeffrey Cornwall (Pearson, 2016)

References

1. Innovation & Entrepreneurship – Peter Drucker (Harper, 2006)
2. Entrepreneurship: The Art, Science, and Process for Success – Charles Bamford & Garry Bruton (McGraw-Hill, 2015)
3. Management and Entrepreneurship-NVR Naidu, T Krishna Rao, I.K. International Publishing House Pvt. Ltd.@ 2008
4. Poornima M Charantimath, Entrepreneurship Development and Small Business Enterprises, Pearson Education, 2006.

Course Outcomes (COs):

At the end of the course, student will be able to

1. Plan and organize for the manpower in the given type of organization (PO-6,9,11)
2. Use staffing Leading and controlling function for the given organization. (PO-6,8,9,10)

3. Understand the fundamentals of entrepreneurship with the goal of fulfilling the requirements of the industries and holding the responsibilities towards the society. (PO-6,7,8)
4. Design a basic business plan by considering case studies and show the involvement of ownership in Business. (PO-3,7,8,11)
5. Start a new small business with the help of E-Commerce and the current available technologies. (PO-5,11)

PROCESS CONTROL	
Subject Code: CH62	**Credits: 2:1:0**
Pre requisites: Laplace Transforms, Process calculations	**Contact Hours: 42L+14T**
Course Coordinator: Dr. D Jaya Prasanna Kumar	

Course content

Unit I

Laplace transforms: Transforms of simple functions, transforms of derivatives, solution of differential equations, inversion by partial fractions, partial fractions.

First order systems: Thermometer, level, mixing tank, STR: Linearization: I order systems in series. Response for various input forcing functions.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103106148
  http://a.impartus.com/ilc/#/course/1254350/1205

Unit II

Second order systems: Characteristics. Transfer functions. Response for various input forcing functions. Transportation lag.

Control System: Basic components, Servo and Regulator control.

Controllers: P.I.D and on-off modes. Controller combinations.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103106148
  http://a.impartus.com/ilc/#/course/1254350/1205

Unit III

Final Control Elements: Valves, actuators, valve positioners, valve characteristics.

Close Loop: Block diagram. Closed loop transfer function.

Transient response of servo and regulator control systems with various controller modes and their characteristics**.**

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103106148
  http://a.impartus.com/ilc/#/course/1254350/1205

Unit IV

Stability: Stability of linear control systems. Routh Test

Root Locus: Root locus techniques, plotting.

Frequency Response – Bode diagrams, Bode criterion.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103106148
  http://a.impartus.com/ilc/#/course/1254350/1205

Unit V

Control system Design by Frequency Response: Gain and Phase margins. Ziegler – Nichols rules. Cohen & Coon tuning method.

Advanced Control Strategies: Cascade Control, Feed Forward Control. Ratio Control.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103106148
  http://a.impartus.com/ilc/#/course/1254350/1205

Text Books:

1. Coughanowr, D.R., Process System Analysis and Control, 3rd Edition, McGraw Hill, 1991.
2. Stephanopolous, G., Chemical Process Control- An Introduction to Theory and Practice, Eastern Economy Edition, 2008.
3. D.E. Seborg, Thomas F. Edgar, D. A. Mellichamp, Process Dynamics and Control, 3rd Edition, Wiley, 2013

Reference Book:

1. Harriott, Process Control, Tata McGraw Hill, 1982.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Learn Laplace transforms, analyze simple I order systems. PO-1,2, PSO-1)
2. Analyze second order systems, different controllers. (PO-1,2,3, PSO-1)
3. Analyze the transient response of feedback systems. (PO-1,2, PSO-1)
4. Design stable control systems for processes. (PO-1,2,3, PSO-1)
5. Understand Frequency Response and tune controllers. (PO-1,5, PSO-1)

PHARMACEUTICAL TECHNOLOGY	
Subject Code: CHE631	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Dr. Ravi Sankannavar	

Course content

Unit I

Concept of fine and bulk drugs and their salient features, Research and development strategies in pharmaceutical industries. Discovering the best synthetic route; Selecting the best route for scale-up, Choice of raw materials, reagents etc

- Pedagogy: Chalk board, power point presentations
- Links: https://www.youtube.com/watch?v=rUMC7c0ytoU
  https://www.youtube.com/watch?v=4m66uajU_Jg

Unit II

Diffusion and dissolution, kinetics and drug stability, Viscosity and rheology, Polymer science and applications.

- Pedagogy: Chalk board, power point presentations
- Links: https://www.youtube.com/watch?v=4lwMrM2Wano
  https://www.youtube.com/watch?v=L9ywC_UFw9M
  https://www.youtube.com/watch?v=54urJPOnaeU

Unit III

Formulations and development, Packaging, Introduction to industrial processing, Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer).

- Pedagogy: Chalk board, power point presentations
- Links: https://www.youtube.com/watch?v=MDg8E7-V8_Q
  https://www.youtube.com/watch?v=Wt8ZZItVzSM

Unit IV

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction), Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying).

- Pedagogy: Chalk board, power point presentations
- Links: https://www.youtube.com/watch?v=-QQm3rFIEWA
  https://www.youtube.com/@chemicalengineering8215

Unit V

Materials of Pharmaceutical Plant Construction, Good Manufacturing Practice (GMP's) Guidelines, process safety considerations.

- Pedagogy: Chalk board, power point presentations
- Links: https://www.youtube.com/watch?v=iQBv19WhP4o
  https://www.youtube.com/watch?v=Z2Jyj1SGyHE

Text Books:

1. Remington: The Science and Practice of Pharmacy ,21st edition, June 2005

Reference Books:

1. Alfred N. Martin, "Physical Chemical and Biopharmaceutical Principles in the Pharmaceutical Sciences", 6th Edn., Lippincott Williams & Wilkins, 2006.
2. David B. Troy, Paul Beringer, "Remington: The Science and Practice of Pharmacy", 21st Edn., Lippincott Williams & Wilkins.
3. Sidney James Carter, "Cooper and Gunn's Tutorial Pharmacy", CBS Publishers & Distributors, 1986.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Acquire basic knowledge of pre-formulation and formulation of drugs, pharmaceutical unit operations and manufacturing, packaging and quality control of pharmaceutical dosage forms. (PO-1, 2, 3, PSO-1)
2. Acquire a knowledge on pharmaceutical unit operations and manufacturing, packaging and quality control of pharmaceutical dosage forms. (PO-1, 2, 3, 4, 6, 8, 10, 11, 12, PSO-1)
3. Trained to conceptualize, design, build up, maintain and operate various industrial processes and machineries involved in the process. (PO-1, 2, 3, 4, 5, 6,7, 8, 9, 10, 11, 12, PSO-1)
4. Understanding and apply the various processing and manufacturing techniques. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, 12, PSO-1)
5. Conduct formulate a pure drug substance into a dosage form. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, 12, PSO-1)

BIOFUELS	
Subject Code: CHE632	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Fundamental concepts in understanding biofuels and bioenergy systems, biomass production, availability and attributes for bioenergy and biofuel production.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/102104057

Unit II

Types of biomass derived fuels and energy, Bioenergy Sources, Characteristics & Classification. Biofuel sources and properties.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/102104057

Unit III

Biogas production from organic matter and animal residues. Fermentation technology in biofuel production.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/102104057

Unit IV

Thermo-chemical and biochemical conversion of biomass to fuel, effect of different parameters on pyrolysis and gasification.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.nptel.ac.in/noc22_ch28/preview

Unit V

Environmental aspects of biofuel production. Sustainability of biofuels production.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/102104057
  https://onlinecourses.nptel.ac.in/noc19_bt16/preview

Text Books:

1. G. N. Tiwari and M. K. Ghosal, *Fundamentals of Renewable Energy Sources*, Narosa Publishing House, 2007
2. Kishore V V N, *Renewable Energy Engineering and Technology, Principles and Practice*, The Energy and Resources Institute (TERI), 2009.

Reference Books:

1. Nijaguna, B.T., *Biogas Technology*, New Age International publishers (P) Ltd., 2002
2. Samir Kumar Khana, *Bioenergy and Biofuel from Biowastes and Biomass*, ASCE Publications, 2010

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain fundamental concepts in biofuels and bioenergy. (PO-1, 6, 7, 9, 10, 12, PSO-3)
2. Explain bioenergy source and their characterization. (PO-1, 6, 7, 9, 10, 12, PSO-3)
3. Demonstrate biogas production. (PO-1, 6, 7, 9, 10, 12, PSO-3)
4. Explain pyrolysis and gasification. (PO- 6, 7, 8, 9, 10, 12, PSO-3)
5. Explain environmental aspects of biofuel. (PO- 6, 7, 8, 9, 10, 12, PSO-3)

ELECTROCHEMICAL TECHNOLOGY	
Subject Code: CHE633	**Credits: 3:0:0**
Pre requisites: Engineering Chemistry	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Introduction to theoretical aspects: Faradays laws, mechanism of conduction in solids, liquids and gases and in ionic melts. Conduction in metals and semiconductors.

- Pedagogy: Chalk board, power point presentations
- Links: Introduction: https://youtu.be/mYGfyO3sPxk
  Electrochemical cells: https://youtu.be/H5Cv2CtKLq8
  Nernst Equation: https://youtu.be/2gBlbEoFzmY, https://youtu.be/JPIGYAtfU30 and https://youtu.be/fHfv41HmIK0
  Laws of electrolysis: https://youtu.be/ksxQUE32AmA
  Applications of Faraday's laws of electrolysis: https://youtu.be/2T1JINsZxsg
  Numerical Problems on Faraday's Laws of Electrolysis: https://youtu.be/nEZGWFFV0ik
  Conductance: https://youtu.be/L_klSpMpqiw, https://youtu.be/56UclUVe560 and https://youtu.be/A4XzBj2zmUg

Unit II

Reversible electrodes and potentials, electrode processes and electrode kinetics. Various types of over potentials. Polarization. Butler-volmer for one electron and mute electron steps. Models of electrical Double layer.

- Pedagogy: Chalk board, power point presentations
- Links: Reversible and Irreversible cell: https://youtu.be/H5Cv2CtKLq8
  Types of Electrodes: https://youtu.be/VvnRU2fecIA
  Electrode kinetics: https://youtu.be/TnR4eolwOrs
  Overpotential: https://youtu.be/C16DBkjaghk
  Polarization: https://youtu.be/iitu-kDQTI0
  Butler-Volmer Equation: https://youtu.be/TnR4eolwOrs and https://youtu.be/UlgqSx-wcps
  Electrical double layer: https://youtu.be/kamimMzfg3k

Unit III

Applied aspects: Potentiometer and ion-selective electrodes. Amperometric and Volta metric electro analysis, Polarography.

- Pedagogy: Chalk board, power point presentations
- Links: Ion-selective electrodes: https://youtu.be/y-eZO86j_zA and https://youtu.be/cjfNJAEDtWQ
  Electrochemical techniques: https://youtu.be/SCEZoFmiUuk, https://youtu.be/PW8xTrt_y0k and https://youtu.be/kbDtm_3zNlA
  Polarography: https://youtu.be/3olOk_xNq8g

Unit IV

Electrode deposition of metals and alloys. Primary, Secondary and Fuel Cells.

- Pedagogy: Chalk board, power point presentations
- Links: Electrodeposition: https://youtu.be/F_6RoLuOVWI
  Batteries and fuel cells: https://youtu.be/-xwVboWt4cs, https://youtu.be/9hbXP5yU-Ug, and https://youtu.be/lA7yWLqpKno

Unit V

Corrosion and its prevention. Electro winning. Electro organic and inorganic synthesis (and some typical examples). Environmental electrochemistry. Bio-electro chemistry**.**

- Pedagogy: Chalk board, power point presentations
- Links: Corrosion: https://youtu.be/LxtDvKOca9w, https://youtu.be/6UfOit5L_BU and
  Electrowinning: https://youtu.be/hEJl0cbGm8g and https://youtu.be/FEncRpDF9UM

Text Books:

1. Bockris, J.O.M., & Reddy, A.K.N., Modern Electrochemistry, Vol.1 & 2, Plenum, New York.
2. Kuhn, Industrial Electrochemical Processes, Elsevier, Amsterdam.
3. James A. Plam Beck, Electroanalytical chemistry- Basic Principles and applications, John Willey & Sons, Wiley Publication, 1982.

Reference Books:

1. Lingane, J.J., Electro Analytical Chemistry, John Wiley, New York.
2. Potter, E.C., Electrochemistry, Principles and Applications, Cleaverhume Press, London.
3. Baizer, M.M., Marcel Dekker, Organic Electrochemistry, John Wiley, New York.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain different fundamental laws of electro chemical technology. (PO-1, PSO-3)
2. Derive different kinetic theories of electrode processes. (PO-1, 2, PSO-1)
3. Apply potentiometric and polarographic principles to practical systems.
4. (PO-1, PSO-3)
5. Design a simple methodology for metals and alloys deposition on surfaces put into practice Primary, Secondary and Fuel Cells. (PO-1, 2, 12, PSO-1)
6. Apply the principles of corrosion and its prevention to different environmental conditions in a chemical process industry. (PO-1, 2, 3,7,12, PSO-1)

CHEMICAL PROCESS OPTIMIZATION	
Subject Code: CHE634	**Credits: 3:0:0**
Pre requisites: Engineering Mathematics IV	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

The Nature and Organization of Optimization Problems: Scope and Hierarchy, Applications, General procedure, obstacles.

Developing models for optimization: Classifications of models, building models, selecting functions to fit empirical data, factorial experimental design, and degrees of freedom.

Basic concepts of optimization: Function continuity, NLP programming, convexity and its application, quadratic approximation, conditions for extremum of an unconstrained function.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105139/

Unit II

Optimization of unconstrained function: One dimensional search: Numerical methods for optimization a function with one variable, Region elimination methods, scanning and bracketing procedure, Methods using derivatives – Newton's method, Bisection method, Secant method, polynomial approximation methods.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105139/

Unit III

Unconstrained multivariable optimization: Methods using functions values only- Random search, grid search, univariate search, Simplex Search, Hooke-Jeeves Pattern Search, and Powell's Conjugate Direction Search.

Gradient- Based Methods – Cauchy's Steepest Descent Method, Conjugate Gradient Method. Newton's method, Quasi Newton's method, Marquardt's Method.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105139/

Unit IV

Linear Programming and its applications: Formulation of linear programs, Graphical solution, Simplex algorithm, Transportation problem.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105139/

Unit V

Nonlinear Programming with constraints: Direct Substitution. First order necessary condition for a local extremum, Lagrange Multiplier Method, KKT Conditions, Quadratic Programming, Generalized Reduced Gradient Method.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105139/

Text Book:

1. Edgar, T.F., Himmelblau, D.M., Ladson, L.S., Optimization of Chemical Processes, McGraw Hill, 2nd Edition, 2001.
2. A Ravindran, KM Ragsdell, GV Reklitis, Engineering Optimization – Methods and Applications, John Wiley & Sons, 2nd Edition, 2006.

Reference Book:

1. SS Rao, Engineering Optimization – Theory and Practice, New Age International (P) Limited, 4th Edition.
2. Kenneth Lange, Optimization, Springer-Verlag, 2004.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Develop objective function and constraint equations for chemical engineering problems. (PO-1, 2, PSO-2)
2. Optimize functions with single variable using numerical methods. (PO-1, 2, PSO-2)
3. Optimize unconstrained functions. (PO-1, 2, 12, PSO-2)
4. Optimize multivariable problems using numerical methods. (PO-1, 2, 12, PSO-2)
5. Apply linear programming methods in optimization. (PO-1, 2, 12, PSO-2)

PRINCIPLES OF FOOD PROCESSING AND PRESERVATION	
Subject Code: CHE635	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Basic consideration: Quality attributes of food, aim and objectives of preservation and processing of foods, food deterioration, and causes of quality deterioration and spoilage of foods, unit operations in food processing.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103107088
  https://archive.nptel.ac.in/courses/126/105/126105015/

Unit II

Low temperature Preservation and Processing of foods: Chilling temperatures: Considerations relating to storage of foods at chilling temperature, applications and procedures, controlled and modified atmosphere storage of foods, post-storage handling of foods.

Freezing temperature: Freezing process, slow and fast freezing of foods and its consequences, other occurrences associated with freezing of foods. Technological aspects of pre-freezing, Actual freezing, frozen storage and thawing of foods.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103107088
  https://archive.nptel.ac.in/courses/126/105/126105015/

Unit III

High temperature preservation and processing of foods: Basic concepts in thermal destruction of Microorganisms-D, Z, F, values Heat resistance and thermophiles in micro-organisms. Cooking, blanching, pasteurization and sterilization of foods. Assessing adequacy of thermal processing of foods, general process of canning of foods, spoilages in canned foods.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103107088
  https://archive.nptel.ac.in/courses/126/105/126105015/

Unit IV

Preservation by Dehydration and concentration: Principles, technological aspects and applications of concentration processes, drying and dehydration of food.

Other techniques in preservation: Food irradiation, microwave heating, ohmic heating

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103107088
  https://archive.nptel.ac.in/courses/126/105/126105015/

Unit V

Processing and preservation of food products: Processing and preservations of milk and milk products, vegetables and food, beverages, meat and meat products.

- Pedagogy: Chalk board, power point presentations
- Links: https://nptel.ac.in/courses/103107088
  https://archive.nptel.ac.in/courses/126/105/126105015/

Text Books:

1. Potter, N.N. and Hotchkiss, J.H., Food Science, 5th Edition, CBS Publishers and Distributors, 2006.
2. Sivasankar, B., Food Processing and Preservation, Eastern Economy Edition, 2005.

Reference Books:

1. Shakuntala, N., Manay and Shadaksharamurthy, M., Foods: Facts and Principles, 3rd Edition, NewAge International, 2008.
2. Subbulakshmi, G., and Udupi, S.A., Food Processing and Preservation, 1st Edition**,** NewAge International, 2006.
3. Sahu, J.K., Fundamentals of Food Process Engineering, Narosa Publishing, 2014.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Know different characteristics of food along with the processing and preservation methods. (PO-1, PSO-1)
2. Explain low temperature preservation and processing systems and for storage of foods. (PO-1, 3, PSO-1)
3. Explain high temperature preservation and processing of foods. (PO-1, 3, PSO-1)
4. Explain other preservation techniques for food. (PO-1, 3, PSO-1, 2)
5. Understand processing and preservation of some important food products. (PO-1, 6, 7, 10, PSO-1)

OPERATIONS RESEARCH	
Subject Code: CHE641	**Credits: 3:0:0**
Pre requisites: Engineering Mathematics I and II	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Introduction: Definition. Scope of Operations Research (OR). Approach and limitations of O.R. Models. Characteristics and phases of O.R.

Linear Programming Problems: Mathematical formulation of L.P. Problems. Graphical solution method.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/110106062

Unit II

Assignment problems: Balanced and Unbalanced assignment problems. Maximization assignment problems. Travelling salesman problems.

Transportation Problem: Basic feasible solutions by different methods. Finding optimal solution. MODI method. Degeneracy. Unbalanced transportation problems. Maximization problems.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/110106062
  https://nptel.ac.in/courses/111107128

Unit III

Sequencing: Johnson's algorithm. n jobs - 2 machines, n jobs -3 machines, and n jobs-n machines without passing sequence. 2 jobs-n machines. Graphical solutions.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.swayam2.ac.in/cec20_ma10/preview

Unit IV

PERT-CPM Techniques: Network construction. Determining critical path. Variance and probability of completing the project. Calculation of different floats. Project duration. Crashing of simple networks.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: http://www.digimat.in/nptel/courses/video/110104073/L21.html

Unit V

Replacement model: Replacement of items which fails completely-individual replacement, group replacement. Replacement of items where maintenance cost increases with time and the value of money changes with time.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.swayam2.ac.in/cec20_ma10/preview

Text Books:

1. Srinath, L. S., Introduction to Pert and CPM, 3rd Edition, East West, 1998.
2. Kantiswaroop, Gupta, P. K. and Manmohan, Operation Research, 9th Edition, S Chand & Co., 1999.

Reference books:

1. Sharma, S. D., Operation Research, 8th Edition, Kedarnath & Co, 2003.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Develop the linear mathematical models for and solve them for their maximization and minimization using graphical and analytical methods. (PO-1, 2, 11, PSO-3)
2. Solve Balanced and Unbalanced Assignment problems and Transportation problems for Maximization and Minimization. (PO-2, 11, PSO-3)
3. Solve problems on Sequencing of jobs in n machines and Inventory for cost analysis. (PO-2, 11, PSO-3)
4. Develop Network construction and determining critical path, Variance and probability of completing the project by PERT-CPM method. (PO-2, 11, PSO-3)
5. Develop model for replacement of individual items, group replacement and maintenance cost analysis. (PO-2, 11, PSO-3)

INDUSTRIAL WASTE WATER TREATMENT	
Subject Code: CHE642	**Credits: 3:0:0**
Pre requisites: Engineering Chemistry & Environmental Studies	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Waste water Engineering – An Overview, Environmental laws pertaining waste water. Norms and standards of treated water.

Sources, sampling and analysis of wastewater: Water resources. Origin of wastewater. Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Types of water pollutants and their effects. Sampling, and methods of analysis. Analysis and selection of waste water flowrates and constituent loadings.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/105/106/105106119/
  https://digimat.in/nptel/courses/video/103107212/L01.html

Unit II

Process Analysis and Selection – Reactors used for the treatment of waste water, Types, applications of reactors, mass balance analysis, modeling ideal flow reactors, non-ideal flow in reactors, modeling treatment process kinetics – batch reactor, complete mix reactors, ideal plug flow reactor, treatment involving mass transfer – gas-liquid mass transfer, liquid-solid mass transfer, Process selection based on reaction kinetics, selection based on mass transfer, selection based on loading criteria, batch tests, pilot plant studies, reliability considerations in process selection.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: http://www.nitttrc.edu.in/nptel/courses/video/105105178/L22.html
  https://archive.nptel.ac.in/courses/105/107/105107207/

Unit III

Wastewater Treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Sludge treatment and disposal. Modern treatment methods. Recovery of materials from process effluents.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/105/107/105107207/

Unit IV

Biological Treatment: Types, biomass growth rates, modeling suspended growth treatment processes, anaerobic fermentation and oxidation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/105/105/105105178/

Unit V

Applications to Industries: Origin, characters, and treatment methods of typical industries – petroleum refinery, pulp and paper, fertilizer, distillery, and textile processing.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://digimat.in/nptel/courses/video/103107212/L56.html

Text Books:

1. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, Environmental Engineering, Mc Graw Hill, 1985.
2. Rao, C.S., Environmental Pollution Control Engineering, New Age International, Reprint 2002.
3. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill, 1999.

Reference Books:

1. Perkins, H.C., Air Pollution, McGraw Hill, 1974.
2. Metcalf and Eddy, Waste Water Engineering, Treatment, Disposal & Reuse, Tata McGraw Hill, 4th Edition, 2003.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain the types of pollutions and their sources and analyze effects of pollutants in water. (PO-1, 2, 3, 4, 6, 7, PSO-1)
2. Design waste water treatment plants depending on the type of industrial waste waters. (PO-1, 2, 3, 4, 6, 7, PSO-1)
3. Identify the sources of air pollution by carrying out air sample analysis and suggest schemes for its prevention. (PO-1, 2, 3, 4, 6, 7, PSO-1)
4. Suggest schemes for processing municipal and industrial solid-wastes. (PO-1, 2, 3, 4, 6, 7, PSO-1)
5. Determine noise levels and suggest suitable technique for abatement of noise levels. Explain industrial process safety needs based on the history and operation methods of a process industry. (PO-1, 2, 3, 4, 6, 7, PSO-1)

HAZARD ANALYSIS AND RISK MANAGEMENT	
Subject Code: CHE643	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Plant Hazards: Fire hazards. Chemical hazards, Toxic hazards, Explosion hazards, Electrical hazards, Mechanical hazards, Radiation hazards, Noise hazards. Control, precautions & prevention, Safety measures in plant.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.nptel.ac.in/noc21_mg59/preview

Unit II

Fire hazards, Chemical hazards, Toxic hazards, Explosion hazards, Electrical hazards, Mechanical hazards, Radiation hazards, Noise hazards, Control, precautions & prevention, Safety measures in plant.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/107/103107156/

Unit III

Storage & Transportation of chemicals: Characteristics of chemical with special reference to safe storage & handling of chemicals, Layout of storage, various modes of transport and Safety precautions in transportation of different types of chemicals.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/107/103107156/

Unit IV

Risk Analysis Techniques: Hazard & Operability (HAZOP) studies, Hazard Analysis (HAZAN), Fault Tree Analysis, and Consequence Analysis.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/110/105/110105094/

Unit V

Onsite and Offsite emergency management plans. Human Error Analysis. Accident Error Analysis. Economics of Risk Management.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/110/105/110105094/

Text Book:

1. K. V. Raghavan and AA. Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
2. V. C. Marshal, Major Chemical Hazards, Ellis Horwood Ltd., Chichester, 1987.
3. Sam Mannan, Lees, Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Classify and identify hazards in chemical industries. (PO-1, 2, 3, 7, PSO, 1)
2. Explain various types of hazards in process industry. (PO-1, 2, 3, 7, PSO, 1)
3. Apply precautions in chemical storage and handling. (PO-1, 2, 3, 7, PSO, 1)
4. Perform fault tree and event tree risk analysis and quantify them. (PO-1, 2, 3, 7, PSO, 1)
5. Train plant personnel and prepare emergency management plans. (PO-1, 2, 3, 7, PSO, 1)

MODELING OF CHEMICAL PROCESSES	
Subject Code: CHE644	**Credits: 3:0:0**
Pre requisites: Engineering Mathematics I and II Momentum Transfer, Process Heat Transfer, Chemical Reaction Engineering-I, Chemical Process Calculations	**Contact Hours: 42L**
Course Coordinator: Chemical Engineering Faculty	

Course content

Unit I

Modelling: Models and model building, principles of model formulations, precautions in model building, Fundamental laws: Review of shell balance approach, continuity equation, energy equation, equation of motion, transport equation of state equilibrium and Kinetics, classification of mathematical models.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/107/103107096/

Unit II

Mathematical Modelling and Solutions to the Following: Basic tank model – Level V/s time. Multi component flash drum. Batch Distillation – Vapour composition with time. Batch Reactor. Solvents extraction (steady & unsteady state), stirred tank (steady state and unsteady state), multistage gas absorption, multistage distillation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://archive.nptel.ac.in/courses/103/105/103105215/

Unit III

Models in heat transfer operation: Heat conduction through cylindrical pipe (steady & unsteady state), cooling of tanks, and unsteady state heat transfer by conduction.

Models in fluid flow operation: Fluid through packed bed column, flow & film on the outside of a circular tube.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.nptel.ac.in/noc22_ch47/preview

Unit IV

Models in Reaction Engineering: Chemical reaction with diffusion in a tubular reactor, chemical reaction with heat transfer in a packed bed reactor, reactor in series.

- Pedagogy/Course delivery tools: Chalk and talk/ppt

- Links: https://archive.nptel.ac.in/courses/103/107/103107096/

Unit V

Introduction to flow sheeting: Property estimation, tearing and flow sheeting, Modular and Equation-solving approach (Elementary treatment only).

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://onlinecourses.nptel.ac.in/noc22_ch47/preview

Text Books:

1. Luyben, W.L., Process Modelling Simulation and Control for Chemical Engineering, 2nd Edition, McGraw Hill, 1990.
2. Babu, B.V., Process Plant Simulation, Oxford Press.

Reference Books:

1. Fogler, H.S., Elements of Chemical Reaction Engineering, 2nd Edition, Prentice Hall, 2001.
2. Smith, J. M. and Vanness, H.C., Introduction to Chemical Engineering Thermodynamics, 5th Edition, MGH 1996.
3. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, Pearson, 7th Edition.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply the shell balance method and application of various equations to simple chemical engineering problems. (PO-1, 2, 3, PSO-1)
2. Develop the models for practical engineering problems of mass transfer. (PO-1, 2, 3, PSO-2)
3. Develop the strategies for development of models for momentum and heat transfer applications. (PO-1, 2, 3, PSO-2)
4. Apply the methods for the transport problems involving reactions also. (PO-1, 2, 3, PSO-2)
5. Apply tools for flow sheeting, parameter estimation and modular approach. (PO-1, 2, 3, PSO-2)

BIOCHEMICAL ENGINEERING	
Subject Code: CHE645	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator: Dr. Rajeswari M Kulkarni	

Course content

Unit I

Introduction: Bioprocess engineering and technology. Role of a Chemical engineer in bioprocess industry. An introduction to basic biological sciences. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Characteristics and control of microorganisms. Environmental and Industrial microbiology.

Biochemistry: Chemicals of Life: Lipids, Sugars, Polysaccharides, Amino acids and proteins, Vitamins, Biopolymers, Nucleic Acids: RNA, DNA and their derivatives (Structure, Biological function and Importance for life only to be studied).

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/105/103105054/# https://archive.nptel.ac.in/courses/102/105/102105064/

Unit II

Enzymes and Proteins: Detailed structure of proteins and enzymes: Primary, Secondary, Tertiary and quaternary. Functions. Production and purification of Enzymes (Methods only). Nomenclature and Classification of enzymes. Mechanism and Kinetics using various models. Kinetics of Enzyme action: Michaelis–Menten rate equation. Derivation with Equilibrium and Pseudo- (quasi-) steady state approximations. Experimental determination of rate parameters: Batch and continuous flow experiments.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/105/103105054/# https://archive.nptel.ac.in/courses/102/105/102105064/

Unit III

Enzyme Inhibition: Effect of Inhibitors (Competitive, noncompetitive, uncompetitive, substrate and product inhibitions), Temperature and pH on the rates enzyme catalyzed reactions.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/105/103105054/#

https://archive.nptel.ac.in/courses/102/105/102105064/

Unit IV

Fermentation Technology: Ideal reactors: A review of Batch and Continuous flow reactors for bio kinetic measurements. Microbiological reactors: Operation and maintenance of typical aseptic aerobic fermentation processes. Formulation of medium: Sources of nutrients. Alternate bioreactor configurations. Introduction to sterilization of bioprocess equipment. Design of batch & continuous sterilization equipment.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/105/103105054/#

Unit V

Growth Kinetics of Microorganisms: Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Models with growth inhibitors, Logistic equation, and Filamentous cell growth model. Continuous culture: Optimum Dilution rate, Critical Dilution rate in Ideal Chemostat. Strategies and Steps involved in product purification.

- Pedagogy: Chalk board, power point presentations
- Links: https://archive.nptel.ac.in/courses/103/105/103105054/#

Text Book:

1. Bailey and Ollis, Biochemical Engineering Fundamentals, 2ndEdition, McGraw Hill, 1976.
2. Shuler, M. L. and Kargi, F., Bioprocess Engineering, 2nd Edition, Prentice Hall, 2002.

Reference Books:

1. Pelczer, Microbiology Concept and Application, 5th Edition, McGraw Hill, 2001 Reprint.
2. Stanbury and Whittaker, Principles of Fermentation Technology, II Edition.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain the basics of microbiology and role of Chemical Engineers in bioprocess industries. (PO-1, 2, 3, 9, 11, 12, PSO-1)
2. Perform kinetic studies of enzymatic reactions to have control over these processes and design such systems. (PO-1, 2, 3, 12, PSO-1)
3. Perform kinetic studies of enzymatic reactions in presence of inhibitors to design such systems to handle them. (PO-1, 2, 3, 12, PSO-1)

4. Explain in details about the fermentation technology, operation and maintenance of equipment in these industries. (PO-1, 2, 3, 12, PSO-1)
5. Explain the kinetics of microbial growth and control of bioreactors. (PO-1, 3, 6, 7, 9, 12, PSO-1).

SIMULATION LABORATORY - I	
Subject Code: CHL65	**Credits: 0:0:1**
Pre requisites: Nil	**Contact Hours: 14P**
Course Coordinator: Dr. Sravanthi	

Course content

List of simulations suggested:

1. Introduction to suggested software available (flow sheeting)
2. Simulations Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater.
4. Process simulation study involving mixing, reactor, distillation, heat exchanger for any of the following;
   a. Ethylene Glycol from Ethylene oxide
   b. Propylene Glycol from Propylene oxide
   c. Aromatic stripper with recycle stream (Benzene, Toluene, Xylene)
   d. Cyclohexane
   e. Ethanol Amine

Software Suggested: ASPEN ONE, HYSYS

Course Outcome (COs):

On successful completion of the course students will be able to

1. Apply process simulation software. (PO-2, 3, 5, 12, PSO-2)
2. Simulate a chemical engineering process. (PO-2, 3, 5, 12, PSO-2)
3. Optimize the parameters in a process using simulation software. (PO-2, 3, 5, 12, PSO-2)

PROCESS CONTROL LABORATORY	
Subject Code: CHL66	**Credits: 0:0:1**
Pre requisites: Nil	**Contact Hours: 14P**
Course Coordinator: Dr. Jaya Prasanna Kumar	

Course content

List of experiments:

1. Thermometer
2. Single tank - Step Response
3. Non Interacting Tanks – Step Response
4. Interacting Tanks – Step Response
5. Pressure Tank
6. U – Tube Manometer
7. Single tank - Impulse Response
8. Non Interacting Tanks – Impulse Response
9. Interacting Tanks – Impulse Response
10. Level/Flow/Pressure/pH/Temperature control – P controller
11. Level/Flow/Pressure/pH/Temperature control – PI controller
12. Level/Flow/Pressure/pH/Temperature control – PD controller
13. Level/Flow/Pressure/pH/Temperature control – PID controller
14. Valve characteristics.
15. Flapper Nozzle System
16. Valve Positioner.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyse various control systems. (PO-2,4,10, PSO-1,3)
2. Evaluate their performance. (PO-2,3,4,10, PSO-1,3)
3. Suggest their applications in process industry. (PO-1,10, PSO-1)

INSTITUTIONAL OPEN ELECTIVE-I

SOLID WASTE MANAGEMENT	
Subject Code: CHOE01	**Credits: 3:0:0**
Pre requisites: Environmental Engineering	**Contact Hours: 42L**
Course Coordinator: Dr. Rama Sivakiran Reddy	

Course content

Unit I

Introduction: Definition, characteristics and perspectives of solid waste. Types of solid waste. Physical and chemical characteristics. Variation of composition and characteristics. Municipal, industrial, special and hazardous wastes.

General aspects: Overview of material flow in society. Reduction in raw material usage. Reduction in solid waste generation. Reuse and material recovery. General effects on health and environment. Legislations.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview

Unit II

Engineered systems: Typical generation rates. Estimation and factors effecting generation rates. On site handling. Storage and processing. Collection systems and devices. Transfer and transport.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview

Unit III

Processing Techniques: Mechanical volume reduction. Thermal volume reduction. Component separation. Land filling and land forming. Deep well injection.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview

Unit IV

Material recovery: Mechanical size alteration. Electromagnetic separation. Drying and dewatering. Other material recovery systems. Recovery of biological conversion products. Recovery of thermal conversion products.

Energy recovery: Energy recovery systems and efficiency factors. Determination of output and efficiency. Details of energy recovery systems. Combustion incineration and heat recovery. Gasification and pyrolysis. Refuse derived fuels (RDF).

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview

Unit V

Case studies: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units.

- Pedagogy: Chalk board, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview

Text Books:

1. Howard S. Peavy, Environmental Engineering, McGraw Hill International Edition, 1986.
2. Dutta, Industrial Solid Water Management and Land Filling Practice, Narose Publishing House, 1999.

Reference Books:

1. Sastry C.A., Waste Treatment Plants, Narose Publishing House, 1995.
2. Lagrega, Hazardous Waste Management, McGraw Hill, 1994.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply knowledge to characterize the solid waste. (PO-1, 2, 4, 9, PSO-1)
2. Understand various components of solid waste and perform calculations. (PO-1, 2, 4, 9, PSO-1)
3. Apply various processing techniques and suitable design considerations for land filling sites. (PO-1, 2, 4, PSO-1)
4. Apply techniques of material recovery and energy recovery from solid waste. (PO-1, 2, 3, 4, PSO-1)
5. Develop a management plan for handling solid waste for various process industries and municipalities. (PO-1, 2,3,4,9, PSO-1)

MINI PROJECT/ DESIGN PROJECT	
Subject Code: CHP67	**Credits: 0:0:3**
Pre requisites: Chemical Process Calculations Process Equipment Design and Drawing	**Contact Hours: 8**
Course Coordinator: Chemical Engineering Faculty	

Course content

A group of students will be assigned a case study, or an analytical problem to be carried out under the supervision of a guide. The group shall not contain more than four students. Guides will be allocated in the beginning of the sixth semester and the problem on design of a process is identified. The project group should complete design project and use software ASPEN PLUS or HYSYS for process simulation studies and submit the report at the end of the semester. The project will be evaluated by the guide and a project co-ordination committee to award the CIE marks as per the rubrics designed by the committee.

Student who is unable to register for Design Project or fails to clear design project can take up a 03 credit NPTEL course approved by the project coordinator of design project and HoD. The student must write the examination and produce the result certificate for the course.

Course Outcomes (COs):

The student should be able to

1. Carry out literature review on selected product and process. (PO- 2, PSO-1)
2. Write material balance, energy balance and thermodynamics for selected process. (PO- 1,2,3, PSO-1)
3. Design and select various equipment's for the process. (PO- 1,2,3,7 PSO-1, 2)
4. Carry out computational and economic analysis (PO- 1, 2, 3, 11, 12, PSO-1, 2, 3)
5. Contribute as team member and prepare precise project report with appropriate reference. (PO-8, 9, 10, 11, 12, PSO-3)

INNOVATION/SOCIETAL/ENTREPRENEURSHIP BASED INTERNSHIP	
Subject Code: INT68	**Credits: 0:0:2**
Pre requisites: Nil	**Contact Hours: -**
Course Coordinator: Chemical Engineering Faculty	

Course content

Students are required to carry out training in a chemical industry or research organization or with a start-up firm for not less than four weeks after 4th or during 5th semester. The internship addresses innovation/societal contributions or should evolve a student's entrepreneurial skill sets. Students are required to submit a report on the same in the format provided by the industrial training committee at the department. The students will be evaluated by the industrial training committee based on the rubrics informed to students by the committee.

Course Outcomes (COs):

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

1. Understand the functioning of the chemical process industry, gain knowledge on the recent developments in the area, and integrate his theoretical knowledge with practical processes. (PO-2,4,7,11,12, PSO-1,2,3)
2. Enhance the communication skills to work in interdisciplinary teams in industry. (PO-9, 10)
3. Realize the professional and ethical responsibility. (PO-6, 7, 8)