



RAMAIAH
Institute of Technology

CURRICULUM
Outcome Based Education
(Academic Year 2026 – 2027)

CHEMICAL ENGINEERING

V & VI Semester B. E

Batch: 2024

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
(Approved by AICTE, New Delhi & Govt. of Karnataka)
Accredited by NBA & NAAC with A⁺ Grade

About the Institute:

In 1962, Dr. M. S. Ramaiah, a visionary philanthropist, established the Gokula Education Foundation with a noble mission to uplift society through education. The same year marked a pivotal moment in technical education in India with the founding of the M S Ramaiah Institute of Technology (MSRIT).

MSRIT offers an impressive array of 18 undergraduate and 15 postgraduate programs, all approved by the All India Council for Technical Education (AICTE). The National Board of Accreditation (NBA) has accredited all eligible programs at the undergraduate (UG) and postgraduate (PG) levels. In March 2021, MSRIT earned an 'A+' grade from the National Assessment and Accreditation Council (NAAC), underscoring its unwavering commitment to academic excellence. Since 2007, the institute has proudly held Autonomous Status for its UG and PG programs, a prestigious recognition granted by the University Grants Commission (UGC) and Visvesvaraya Technological University (VTU). According to the Ministry of Education, Government of India's NIRF Ranking Framework, MSRIT ranks 75th among 1,584 leading engineering institutions and 31st among 131 architecture schools in India for 2025, highlighting its remarkable impact and leadership in education.

The institute participated in the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. To foster a research culture, the institute has established several specialized centres, including the Centre for Imaging Technologies, the Centre for Advanced Materials Technology, the Centre for Antennas and Radio Frequency Systems (CARFS), the Centre for Cyber Physical Systems, the Schneider Centre of Excellence, the Centre for Bio and Energy Materials Innovation, JSW Centre of Excellence in Power Systems and more. MSRIT boasts a faculty of 380 highly qualified members, 70% of whom hold doctoral degrees, and over 300 scholars currently pursuing Ph.D. degrees.

The Entrepreneurship Development Cell (EDC) and "Ramaiah Evolute" have been established on campus to support startup incubation. MSRIT features a dedicated Placement and Training department, a strong mentoring and proctorial system, a fully equipped sports department, and a spacious, air-conditioned library with a wide range of books and subscriptions to both international and national journals. The Digital Library provides access to online e-journals from renowned publishers, including Elsevier ScienceDirect, IEEE, Taylor & Francis, and SpringerLink. Additionally, the Institute is a member of DELNET, CMTI, and the VTU E-Library Consortium.

The institute features a state-of-the-art auditorium, a well-equipped recording studio, and multiple advanced conference halls with videoconferencing capabilities. Additionally, MSRIT provides excellent hostel accommodations for both boys and girls, ensuring a comfortable living environment. MSRIT alumni have achieved remarkable success, holding prominent positions in India and internationally. They maintain strong connections with the institute through an engaged and active Alumni Association.

Founded on Dr. Ramaiah's unwavering commitment to knowledge and innovation, this remarkable institution continues to inspire generations of students and shape the future of engineering and technology in the country.

About the Department

Established in 1978, the Department of Chemical Engineering at MSRIT was the fifth department launched by the institute. It began with an intake of 40 students, later increased to 60 in 2002. The department has steadily advanced toward achieving its mission and is now recognized as a significant contributor to Chemical Engineering education in India. Accredited Four times in succession by the National Board of Accreditation, the department has also earned an 'A+' grade from NAAC. More than 2500 students have graduated across 44 batches. The department offers robust infrastructure, and its students have received various prestigious awards, participated in international internships, and earned high accolades for their innovative projects. Faculty members possess diverse expertise and are actively engaged in advanced technological research.

The department is a VTU-approved Research Centre, offering M.S (by Research) and Ph.D. programs. The alumni of the department have held prominent positions in industry and academia around the world. Many alumni are entrepreneurs, contributing actively to nation-building. Under the aegis of the IIChE Student Chapter, the department organizes enriching industry interactions and encourages student development. A range of research projects, sponsored by DRDO, VTU, IEI, and KSCST have been successfully led by the department. The department also hosts the Bangalore Regional Centre of the Indian Institute of Chemical Engineers, which has been operating for nearly two decades from the department. In 2011, MSRIT proudly organized CHEMCON-2011, the flagship event of the Indian Chemical Engineering Congress, drawing top chemical engineering professionals across the globe.

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

RIT 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):

PEO1: 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.

PEO2: To produce graduates who are prepared to pursue their post-graduation and Research in the emerging and allied areas of Chemical Engineering and Business.

PEO3: To produce graduates who possess skills with professional integrity and ethics to assume professional leadership roles and administrative positions.

PEO4: To provide students with opportunities to integrate with multidisciplinary teams to develop and practice written and oral communication skills.

PROGRAM OUTCOMES (POs):

On completion of 4 year B.E. Degree program, Chemical Engineering graduates will be able to:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8).

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 2024-28

Semester	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Course Category									
Basic Science Course (BSC)	08	08	03	03	---	---	---	---	22
Engineering Science Courses(ESC/ PLC/ETC)	08	09	---	---	---	---	---	---	17
Humanities, Social Sciences and Management (HSMC)	02	02	---	---	03	03	---	---	10
Ability Enhancement Course (AEC)	02	01	01	01	01	---	---	---	06
Skill Development Course (SDC)	---	---	---	---	---	01	02	---	03
Universal Human Values (UHV)	---	---	02	---	---	---	---	---	02
Professional Courses Core (PCC)	---	---	11	12	12	06	04	---	45
Integrated Professional Core Course (IPCC)	---	---	04	04	03	---	04	---	15
Professional Electives Courses - (PEC)	---	---	---	---	03	06	03	---	12
Open Elective Courses (OEC)	---	---	---	---	---	03	03	---	06
Internship (INT)	---	---	---	---	---	---	---	05	05

Mini Project/ Project Work(PW)	---	---	---	---	---	04	---	13	17
Non Credit Mandatory Courses (NCMC)	---	---	---	Yes	Yes	Yes	---	---	---
Total Credits	20	20	21	20	22	23	16	18	160

B.E.in Chemical Engineering
SCHEME OF TEACHING V SEMESTER Batch:2024

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total contact hours /week			
					L	T	P	Total	L	T	P	S
1	CH51	Chemical Reaction Engineering - II	Chemical Engineering	PCC	2	1	0	3	2	2	0	2
2	CH52	Process Equipment Design	Chemical Engineering	IPCC	1	1	1	3	1	2	2	1
3	CH53	Chemical Process Industries	Chemical Engineering	PCC	3	0	0	3	3	0	0	3
4	CH54	Mass Transfer-II	Chemical Engineering	PCC	3	1	0	4	3	2	0	3
5	CHE55X	Program Elective Course - 1	Chemical Engineering	PEC	3	0	0	3	3	0	0	3
6	CHL56	Mass Transfer Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
7	CHL57	Computational Methods Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
8	AL58	Research Methodology and Intellectual Property Rights	Chemical Engineering	HSMC	3	0	0	3	3	0	0	3
9	CHAE59	Ability enhancement course- V Process Instrumentation	Chemical Engineering	AEC	1	0	0	1	1	0	0	1
Total					16	3	3	22	16	6	6	6
10	HS510	Environmental Studies *		NCMC	0	0	0	0				

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 Sources and Technology		

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

NOTE: Minimum of 1 subject should have a Tutorial component of 1 Credit.

Nomenclature: **IC:** Integrated Course (Practical Integrated with Theory Course), **PCC:** Professional Core Course, **PEC:** Professional Elective Course, **AEC:** Ability Enhancement Course, **NCMC:** Non-credit Mandatory Course

Credit Definition:

- **1 credit = 1 hour/week of lecture (L)**
- **1 credit = 2 hours/week of tutorial (T)**
- **1 credit = 2 hours/week of practical(P)**
- **Self-Learning Hours (S)**

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

PCC(IC) is an Integrated course, combining theory with practical components.

- Theory sessions shall be conducted for 3 hours per week, while the practical sessions shall be conducted for 2 hours per week.

- Theory components shall be evaluated through both Continuous Internal Evaluation (CIE) and Semester End Examination (SEE).
- The practical component shall be assessed only through CIE (No SEE).
- The CIE shall consist of two internal test of 30 marks each. Each test will have three questions and student shall answer any two full questions. Each question shall have all CO's addressed for that test. An average of two test shall be taken to award 30 marks.
- The CIE for the practical component shall be evaluated for 20 marks. Each laboratory experiment shall be evaluated for 10 marks based on the experiment record, conduction of the experiment, and observations, and the cumulative marks shall be scaled down to 15 marks. Another 05 marks from a lab test and viva.
- The SEE shall be evaluated for 100 marks, which shall be scaled down to 50 marks.
- The SEE examination shall consist of 10 questions with internal choice and student shall answer any five full questions.
- However, questions from the practical component of the Integrated course (IC) can be included in the SEE question paper.

PCC & PEC courses are theory courses with or without tutorial sessions.

- Each theory credit corresponds to one contact hour per week, while each tutorial credit corresponds to two contact hours per week.
- The course shall be evaluated through Continuous Internal Evaluation (CIE) and Semester End Examination (SEE), each having a weightage of 50%.

- The CIE is evaluated for 50 marks through internal tests (30 marks) and other components (20 marks). Each internal test will have three questions and students shall answer any two full questions. Each question shall address all the Course Outcomes (COs) prescribed for that test. The average of the two tests shall be considered for awarding 30 marks. The remaining 20 marks shall be assessed through assignments, tutorial tests, quizzes, surprise tests, mini-projects, or other components as decided by the course instructor.
- The SEE shall be evaluated for 100 marks, which shall be scaled down to 50 marks.
- The SEE examination shall consist of ten questions with internal choice (two questions per unit). Students shall answer any five full questions, selecting at least one question from each unit.

NOTE: Professional Elective Courses shall have minimum students' strength for offering open electives as 10. However, this condition shall not be applicable to cases where the admission to the program is less than 10.

AEC is a 1-credit course involving 1 contact hour per week. The course shall be evaluated through Continuous Internal Evaluation (CIE) and Semester End Examination (SEE), each having a weightage of 50%.

- The CIE will comprise of two tests of 30 marks each having Part-A with MCQs for 6 marks and Part-B with Descriptive questions. The remaining 20 marks shall be assessed through assignments, surprise tests, quizzes, or other components as decided by the course instructor.
- The SEE will comprise of Part-A with MCQs (10 marks) and Part-B (5x8=40 marks) with descriptive questions.

PCC Laboratory is a 1-credit lab course involving 2 hours of lab sessions per week and uses both Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) for assessment.

- CIE totals 50 marks, with 30 marks for lab sessions (Each laboratory experiment shall be evaluated for 10 marks based on the experiment record, conduction of the experiment, and observations, and the cumulative marks shall be scaled down to 30 marks.). Another 15 marks from a lab test and 05 marks for viva.
- SEE totals 50 marks, comprising 40 marks for procedure write up, experiment conduction & results and 10 marks for viva voce.

AICTE Activity Points Requirement for BE Programs: As per AICTE guidelines (refer Chapter 6 – *AICTE Activity Point Program, Model Internship Guidelines*), in addition to academic requirements, students must earn a specified number of **Activity Points** to be eligible for the award of the degree. The points to be earned is:

1. **Regular students** admitted to a 4-year degree program must earn **100 Activity Points**.
2. **Lateral entry students** (joining from the second year) must earn **75 Activity Points**.
3. **Students transferred** from other universities directly into the V semester must earn **50 Activity Points** from the date of entry into VTU.

These Activity Points are non-credit and will not be considered for the SGPA/CGPA or be used for vertical progression. However, earning Activity Points is mandatory for the award of the degree, and the points earned will be reflected on the eighth semester Grade Card. If a student completes all the semesters (eight or six) at the end of the program but fails to earn the required Activity Points, the VIII semester Grade Card will be withheld until the requirement is fulfilled. Also, the degree will be awarded only after the Grade Card has been released. The hours spent earning the activity points will not be counted for regular attendance requirements. Students can accumulate these points at any time

during their program period, including weekends, holidays, and vacations, starting from the year of admission, provided they meet the minimum hours of engagement prescribed for each activity by AICTE.

The Non-Credit Mandatory Course, Environmental Studies: 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 fulfill 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.

B.E.in Chemical Engineering
SCHEME OF TEACHING VI SEMESTER Batch:2024

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total Contact hours /week			
					L	T	P	Total	L	T	P	S
1	AL61	Management & Entrepreneurship	Chemical Engineering	HSMC	3	0	0	3	3	0	0	3
2	CH62	Process Control	Chemical Engineering	PCC	3	1	0	4	3	2	0	3
3	CHE63X	Program Elective Course - 2	Chemical Engineering	PEC	3	0	0	3	3	0	0	3
4	CHE64X	Program Elective Course - 3	Chemical Engineering	PEC	3	0	0	3	3	0	0	3
5	CHL65	Simulation Lab - I	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
6	CHL66	Process Control Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
7	CHOE01*	Open Elective - 1	Chemical Engineering	OEC	3	0	0	3	3	0	0	3
8	CHP67	Mini Project (Experimental/Design)	Chemical Engineering	PW	0	0	4	4	-	-	-	-
9	CH68	Technical skill enhancement course(Industry Supported Course)	Industry Expert	SDC	0	1	0	1	0	2	0	0
Total					15	2	6	23	15	4	4	15
10	PE69	Physical Education		NCMC	All students have to register compulsorily for any one of the courses with the concerned coordinator							
	YO69	Yoga										

	NS69	NSS			(Yoga Teacher/ Physical Education Director/ NSS Coordinator) in the beginning of the III semester. Attending the registered course from III to VI semesters. Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree.
--	------	-----	--	--	--

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		

NOTE: Minimum of 1 subject should have a Tutorial component of 1 Credit.

Nomenclature- **PCC:** Professional Core Course, **PEC:** Professional Elective Courses, **OEC:** Open Elective Course, **PW:** Mini Project, **SDC:** Skill Development Course, **NCMC:** Non-credit Mandatory Course, **INT:** Internship

Credit Definition:

- **1 credit = 1 hour/week of lecture (L)**
- **1 credit = 2 hours/week of tutorial (T)**
- **1 credit = 2 hours/week of practical(P)**

- **Self-Learning Hours (S)**

Note: XxE63x, where x=1,2,3,4,5

PCC & PEC & HSMC courses are theory courses with or without tutorial sessions.

- Each theory credit corresponds to one contact hour per week, while each tutorial credit corresponds to two contact hours per week.
- The course shall be evaluated through Continuous Internal Evaluation (CIE) and Semester End Examination (SEE), each having a weightage of 50%.
- The CIE is evaluated for 50 marks through internal tests (30 marks) and other components (20 marks). Each internal test will have three questions and students shall answer any two full questions. Each question shall address all the Course Outcomes (COs) prescribed for that test. The average of the two tests shall be considered for awarding 30 marks. The remaining 20 marks shall be assessed through assignments, tutorial tests, quizzes, surprise tests, mini-projects, or other components as decided by the course instructor.
- The SEE shall be evaluated for 100 marks, which shall be scaled down to 50 marks.
- The SEE examination shall consist of ten questions with internal choice (two questions per unit). Students shall answer any five full questions, selecting at least one question from each unit.

NOTE: Professional Elective Courses shall have minimum students' strength for offering open electives as 10. However, this condition shall not be applicable to cases where the admission to the program is less than 10.

PCC Laboratory is a 1-credit lab course involving 2 hours of lab sessions per week and uses both Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) for assessment.

- CIE totals 50 marks, with 30 marks for lab sessions (Each laboratory experiment shall be evaluated for 10 marks based on the experiment record, conduction of the experiment, and observations, and the cumulative marks shall be scaled down to 30 marks.). Another 15 marks from a lab test and 05 marks for viva.
- SEE totals 50 marks, comprising 40 marks for procedure write up, experiment conduction & results and 10 marks for viva voce.

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 which will provide a platform to students to enhance their practical knowledge and skills by 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 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 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 project work report, project presentation skill and question and answer session.

Technical Skill Enhancement Course: is a 1-credit tutorial course with 2 contact hours per week. This course is designed to improve the practical and technical skills of students, focusing on developing industry-relevant and job-oriented skills, and enhance employability of the students. The course teacher shall be an industry expert who provides hands-on experience with relevant tools and technologies currently existing in the industry. The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. The course shall be evaluated by the industry expert through Continuous Internal Evaluation (CIE) for 100 marks.

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 fulfill 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.

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 VIII 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. In case student fail to earn the prescribed activity points; 8th 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 VIII semester grade card.

Note: Internship: All the students shall have to undergo mandatory internship of 6 – 8 weeks during the intervening vacation of the IV & V semesters, intervening vacation of VI & VII semesters, VII semester. A Viva-voce based CIE examination shall be conducted during the VIII semester as per the rubrics defined by the department and the prescribed credits shall be included in VIII semester grade card.

SEMESTER V

CHEMICAL REACTION ENGINEERING - II	
Subject Code: CH51	Credits: 2:1:0
Pre requisites: Chemical Reaction Engineering-II	Contact Hours: 30L+30T+30S
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://nptel.ac.in/courses/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://nptel.ac.in/courses/103103026>

Unit III

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

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://nptel.ac.in/courses/103106117>

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://nptel.ac.in/courses/103107220>

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://nptel.ac.in/courses/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. Elucidate 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. Comprehend various types of reactors. (PO-1,2,3,4, PSO-1,2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3, CO4, CO5
Quiz/Research Paper	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

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: 15L+30T+30P+15S
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 pressure vessels ensuring compliance with industry standards. (PO- 1, 2, 3, 5, 7, 8, 9, PSO-1, 2, 3)
2. Design of process equipment's as per the industry standards. (PO- 1, 2, 3, 5, 7, 8, 9, PSO-1, 2, 3)
3. Perform the mechanical design and use of AutoCAD to create technical drawings of the designed equipment's. (PO- 1, 2, 3, 5, 7, 8, 9, PSO-1, 2, 3).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO1, CO2, CO3
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Lab experimental work & Record writing	10	CO1, CO2, CO3
Assignment/Quiz	10	CO1, CO2, CO3
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3

CHEMICAL PROCESS INDUSTRIES	
Subject Code: CH53	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. AVSL Sai Bharadwaj	

Course Content

Unit I

Sulfur: Elemental Sulfur mining, Sulfur from ores, Oxides of Sulfur (SO₂, SO₃).

Industrial Gases: CO₂, H₂, O₂, N₂, Water gas.

Acids: Sulfuric, Nitric, Hydrochloric, phosphoric acid.

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

- **Links:**

<https://www.youtube.com/watch?v=vvVkiy3v064&list=PLwdnzlV3ogoXiqskIIVkGJX6opfz03t19>

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://www.youtube.com/watch?v=vvVkiy3v064&list=PLwdnzlV3ogoXiqskIIVkGJX6opfz03t19>

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://www.youtube.com/watch?v=vvVkiy3v064&list=PLwdnzlV3ogoXiqskIIVkGJX6opfz03t19>

Unit IV

Petroleum Industries: Constituents of crude petroleum refining and catalytic cracking

Natural Product Industries: Vegetable oils, pulp and paper and sugar industry

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

- **Links:**

<https://www.youtube.com/watch?v=wwVkiy3v064&list=PLwdnzlV3ogoXiqskIIVkGJX6opfz03t19>

Unit V

Polymers and Rubber: Polymerization, PVC, LDPE, Polypropylene, polyester, synthetic fibers, natural rubber, synthetic rubber and rubber compounding, thermoplastic and thermosetting plastics

Miscellaneous Industries: Paints, Pigments, Varnishes, Enamels, manufacture of Portland cement.

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

- **Links:**

<https://www.youtube.com/watch?v=wwVkiy3v064&list=PLwdnzlV3ogoXiqskIIVkGJX6opfz03t19>

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- 1,3,7, PSO- 1)
2. Elucidate manufacturing process based on reactions, operations involved in the production of chlor-alkali chemicals and fertilizer industries. (PO- 1,3,7, PSO- 1)
3. Elucidate and develop the material requirements, flow diagrams in the manufacturing of phosphorous based chemicals and fermentation industries. (PO- 1,3,7, PSO- 1)
4. Design based on the knowledge of processing of crude petroleum and natural products (PO- 1,3,7, PSO- 1)

5. Develop flow chart and explain the production of polymer based chemicals, rubber and miscellaneous industries. (PO- 1,3,7, PSO- 1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments/Quiz	10	CO1, CO2
Assignments/Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MASS TRANSFER-II	
Subject Code: CH54	Credits: 3:1:0
Pre requisites: Mass Transfer-II	Contact Hours: 45L+30T+45S
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. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Dutta, B.K., Mass Transfer Principles and Separation Processes, 1st Edition, PHI, 2006.
3. Narayanan, K.V., Lakshmikutty, B., Mass Transfer - Theory and Practice, 1st Edition, CBS, 2014.

Reference Books:

1. Foust, A., Principals of Unit Operation, 2nd Edition, John Wiley, 1994.
2. 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. Elucidate absorption, desorption operations and design equipments. (PO- 1, 2, 3, PSO-1)
2. Analyze vapor-liquid equilibrium, single stage and batch operation. (PO- 1, 2, 3, PSO-1)
3. Design equipment for continuous rectification. (PO- 1, 2, 3, PSO-1)

4. Analyze liquid-liquid and solid-liquid extraction and select/design such operations. (PO- 1, 2, 3, PSO-1)
5. Understand working of equipment's for membrane separation operations. (PO- 1, 2, 3, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3, CO4, CO5
Assignments /Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MATERIAL SCIENCE	
Subject Code: CHE551	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. Ashwini Wali	

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 and talk, power point presentations
- Links: <http://digimat.in/nptel/courses/video/113102080/L01.html>

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 and talk, power point presentations
- Links: <http://digimat.in/nptel/courses/video/113102080/L01.html>

Unit III

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

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

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

- Pedagogy: Chalk and talk, power point presentations
- Links: <http://digimat.in/nptel/courses/video/113102080/L01.html>

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 and talk, power point presentations
- Links: <http://digimat.in/nptel/courses/video/113102080/L01.html>

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 and talk, power point presentations
- Links: <http://digimat.in/nptel/courses/video/113102080/L01.html>

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, Addison-Wesley 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)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3, CO4, CO5
Assignments /Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

PETROLEUM REFINING TECHNOLOGY	
Subject Code: CHE552	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. J Koteswara Rao	

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ch64
- <https://www.youtube.com/watch?v=GqF0V8tZ6zo>

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ch64
- <https://www.youtube.com/watch?v=GqF0V8tZ6zo>

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ch64
- <https://www.youtube.com/watch?v=GqF0V8tZ6zo>

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ch64
- <https://www.youtube.com/watch?v=GqF0V8tZ6zo>

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ch64
- <https://www.youtube.com/watch?v=GqF0V8tZ6zo>

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. Analyse different types of crude and their composition. (PO-1, 2, 3, 4, PSO-1)
2. Elucidate crude pretreatment methods and operations involved. (PO-1, 2, 3, 4, PSO-1)
3. Elucidate impurities present in the crude and treatment methods. (PO-1, 2, 3, 4, 7, PSO-1)
4. Comprehend various petroleum cracking process. (PO-1, 2, 3, 4, 7, PSO-1)
5. Understand crude processing methods. (PO-1, 2, 3, 4, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Mini Project	10	CO1, CO2, CO3, CO4, CO5
Quiz/Presentations	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

NON-CONVENTIONAL ENERGY SOURCES AND TECHNOLOGY	
Subject Code: CHE553	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. AVSL Sai Bharadwaj	

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, Synthesis of solar fuels

- Pedagogy: Chalk and talk, power point presentations
- Links: https://www.youtube.com/watch?v=gx_bt63lTxw

Unit II

Biodiesel Production and Applications: Feedstocks can be used, Pros and Cons of Feedstocks, catalysts to be used in the synthesis process, catalyst characterization process, application of synthesized catalyst in biodiesel production through transesterification process, performance and emission analysis of synthesized biodiesel.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://www.youtube.com/watch?v=kS1OEZrXdvs>

Unit III

Biomass-Biofuel Production: Sources for bioethanol production, different synthesis processes for bioethanol production: Types of Pretreatment, Hydrothermal liquefaction, Pyrolysis. Biogas production (including digesters), Application of synthesized biofuel. **Algal Biofuels:** Sources for algal biofuel production, environmental significance of selected feedstock, life cycle of algal biofuels, advantages and disadvantages of algal biofuels.

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

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 and talk, power point presentations
- Links: <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 and talk, power point presentations
- Links: https://www.youtube.com/watch?v=62363H_I_Qk

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.
3. David M. Mousdale, Introduction to Biofuels, CRC Press, Taylor & Francis publications, 2010.

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. Analyze the importance of solar energy, applications, and solar fuels. (PO-1, 7, PSO-1).
2. Explain the production of biodiesel from various sources. (PO-1, 6, 7, 9, 10, PSO-1, 3).
3. Explain the synthesis of biofuels and algal biofuels from biomass. (PO- 1, 6, 7, 9, 10, PSO-3)
4. Elucidate technologies of Wind energy and ocean. (PO-1, 7, PSO-1)
5. **Study** about the significance of fuel cells over batteries. (PO-1, 7, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO1, CO2
Assignment /Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

INTERFACIAL PHENOMENA AND SURFACE ENGINEERING	
Subject Code: CHE554	Credits: 3:0:0
Pre requisites: Chemical Engineering Thermodynamics	Contact Hours: 45L+45S
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. Elucidate mechanical and thermodynamic approaches to interface and derive the equation for excess pressure across different surfaces. (PO-1, PSO-1)
2. Comprehend different methods of interfacial tension measurement. (PO-1, PSO-1)
3. Elucidate concepts of kinetics of spreading, contact angle hysteresis. (PO-1, 2, PSO-1)
4. Interpret electrical aspects of surfaces. (PO-1, 2, PSO-1)
5. Elucidate thermodynamic and mass transfer considerations of surfactants. (PO-1, 2, PSO-1)

POLYMER PROCESSING TECHNOLOGY	
Subject Code: CHE555	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
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 and talk, 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 and talk, 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 and talk, 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 and talk, 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 and talk, 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. Study the significant principles of processing of polymers. (PO-1, 2, 3, PSO-1)
2. Understand the main concepts of polymer extrusion. (PO-1, 2, 3, PSO-1)
3. Test the manufactured polymer for suitability through injection moulding. (PO-1, 2, 3, PSO-1)
4. Importance of compression moulding, characteristics of polymer for calendaring, Application of PVC products. (PO-1, PSO-1)
5. Study the importance of thermoforming and rotational moulding. (PO-1, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO1, CO2
Assignment /Quiz	10	CO3, CO4, CO5
Semester End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MASS TRANSFER LABORATORY

Subject Code: CHL56	Credits: 0:0:1
Pre requisites: Mass Transfer	Contact Hours: 30P
Course Coordinator: Dr. Rajeswari M Kulkarni/ Dr. Ashwini Wali	

Course Content

List of experiments suggested:

1. To determine the diffusion coefficients (diffusivity) of Acetone in air at room temperature.
2. To study the drying characteristics of given sample, wet sand in a single tray dryer.
3. To verify Rayleigh equation by carrying out simple distillation on Carbon Tetrachloride-Toluene mixture.
4. To verify the Himus equation and find the constants of the equation.
5. To find the effect of solvent quantity in single stage leaching.
6. To find the effect of solvent quantity in multi stage leaching.
7. To verify Freundlich equation by adsorbing oxalic acid on activated carbon from an oxalic acid solution and calculate the constants of the equation.
8. To determine the height equivalent to theoretical packing for distillation of methanol-water system in a packed column.
9. To determine the percentage recovery of acetic acid (solute) with different amount of solvents from a solution of benzene- acetic acid using water as solvent by single stage extractions.
10. To determine the percentage recovery of acetic acid (solute) from a solution of benzene- acetic acid using water as solvent multistage, cross current extractions.
11. To verify the principle of immiscible liquid mixture boiling and find the vaporization and thermal efficiencies.
12. To study solid dissolution with instantaneous reaction and to compare the experimental enhancement factor with those predicted by boundary layer and film models.
13. To determine the diffusion coefficients (diffusivity) of Methanol in air at room temperature.
14. To determine the height equivalent to theoretical packing for distillation of Toluene-Carbon Tetra Chloride system in a packed column.
15. To study the drying characteristics of given sample, wet calcium carbonate in a single tray dryer.

Text Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.

Course Outcome (COs):

The student will be able to

1. Comprehend the working principles of mass transfer equipment's. (PO-1, 2, 8, 9, 10, PSO-1, 3)
2. Evaluate the performance of mass transfer equipment's. (PO-1, 2, 8, 9, 10, PSO-1, 3)
3. Suggest their applications in process industry. (PO-1, 2, 8, 9, 10, PSO-1, 3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test	20	CO1, CO2, CO3
Other Components		
Conduction, Calculation, Record and Viva	30	CO1, CO2, CO3
Semester-End Examination (SEE)	50	CO1, CO2, CO3

COMPUTATIONAL METHODS LAB	
Subject Code: CHL57	Credits: 0:0:1
Pre requisites: Engineering Mathematics IV Fundamentals of Computing	Contact Hours: 30P
Course Coordinator: Dr. Brijesh	

Course Content

List of programmes: (C, Python, MS Excel and Sci lab):

1. 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. Implement C programs/ MS Excel for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2, 3)
3. Implement Sci lab programs for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2, 3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test	20	CO1, CO2, CO3
Other Components		
Conduction, Calculation, Record and Viva	30	CO1, CO2, CO3
Semester-End Examination (SEE)	50	CO1, CO2, CO3

RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	
Subject Code: AL58	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. 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: NPTEL Prof. G Phani Kumar

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: NPTEL Prof. Soumitro Banerjee <https://nptel.ac.in/courses/127106227>

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: Nptel: Prof. Arun K Thangirala and Prof. Soumitro Banerjee
<https://nptel.ac.in/courses/127106227>

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 Presentation
- Links: Nptel: Prof. K. D. Raju, Prof. Niharika Sahoo Bhattacharya
<https://nptel.ac.in/courses/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: Nptel: Prof. K. D. Raju, Prof. Niharika Sahoo Bhattacharya
<https://nptel.ac.in/courses/110105139>

Text Books:

1. C. R Kothari, Gourav Garg, Research Methodology – Methods and Techniques. New Age International Publishers.
2. 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>.
3. B L Wadehra – Law relating to Intellectual property. Universal Law Publishing Co.

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. Classify different types of research and conduct a literature review. (PO: 1, 2, 7, 9, 11)
2. Apply the knowledge of research design and design of experiments. (PO: 1, 2, 7, 8, 11)
3. Analyse data collection methods, analysis, and sampling design. (PO: 1, 3, 4, 7, 8, 9, 11).
4. Understand the global and Indian scenarios of patents and patent applications. (PO: 1, 6, 7, 9, 11)
5. Understand the process of registration and infringements related to trademarks, copyrights, and designs. (PO: 1, 6, 7, 9, 11)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO1, CO2, CO4, CO5
Surprise Test	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

ABILITY ENHANCEMENT COURSE – V PROCESS INSTRUMENTATION	
Subject Code: CHAEC59	Credits: 1:0:0
Pre requisites: Nil	Contact Hours: 15L+15S
Course Coordinator: Dr. Rajeswari M Kulkarni	

Course Content

Unit I

Elements of Instruments: static and dynamic characteristics, basic concepts of response of first order type instruments, mercury in glass thermometer, bimetallic thermometer.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- NPTEL: Chemical process instrumentation, Dr.Debasis Sarkar

Unit II

Thermo Electricity: Industrial thermocouples, thermocouple wires, thermo couple wells and response of thermocouples. photoelectric and optical pyrometers.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- NPTEL: Chemical process instrumentation, Dr.Debasis Sarkar

Unit III

Composition Analysis: spectroscopic analysis by absorption, emission, mass and color measurement spectrometers, gas chromatography, refractometer. Head flow meters, area flow meters and open channel meters.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- NPTEL: Chemical process instrumentation, Dr.Debasis Sarkar

Unit IV

Pressure vacuum and head: liquid column manometers, measuring elements for gauge pressure and vacuum. Head, density and specific gravity, direct measurement of liquid level, pressure measurement in open vessels, level measurements in pressure vessels.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- NPTEL: Chemical process instrumentation, Dr.Debasis Sarkar

Unit V

P&ID Instrumentation symbols and diagrams, process analysis, flow diagram construction and case studies.

- Pedagogy: Chalk and Talk, PowerPoint Presentations

- NPTEL: Chemical process instrumentation, Dr. Debasis Sarkar

Text Books:

1. Industrial instrumentation by Donald P. Eckman, Wiley Eastern.

Reference Books:

1. Principles of industrial instrumentation by Patra Nabis, TMH.
2. Instruments for measurements and control by Holbrock W.C. Van Nostrand East West.
3. Hand book Instrumentation, Considine, McGraw Hill.

Course Outcomes (COs):

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

1. Analyze the elements of instruments, characteristics of instruments and working of thermometers and their response. (PO-1,8,9,11, PSO-1)
2. Understand the principles and applications of thermoelectric devices and thermometers. (PO-1,8,9,11, PSO-1)
3. Apply spectroscopic and chromatographic techniques for composition analysis and also learn working of flowmeters. (PO-1,8,9,11, PSO-1)
4. Evaluate methods for pressure, vacuum, and level measurements in various conditions. (PO-1,8,9,11, PSO-1)
5. Developing process instrumentation flow diagram and performing process analysis. (PO-1,5,8,9,11, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Report	10	CO1, CO2, CO3
Case Study/Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

ENVIRONMENTAL STUDIES	
Subject Code: HS510	Credits: 0:0:0
Pre requisites:	Contact Hours: 15L
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)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments/Quiz	10	CO1, CO2
Assignments/Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

VI SEMESTER

MANAGEMENT & ENTREPRENEURSHIP	
Subject Code: AL61	Credits: 3:0:0
Pre requisites: NIL	Contact Hours: 45L+45S
Course Coordinators: Dr. M Shilpa/ Dr. M Rajesh	

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 and Talk, PowerPoint 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 and Talk, PowerPoint 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 and Talk, PowerPoint 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.

Launching the Business: Franchising and the Entrepreneur: Types of Franchising, the benefits of buying a Franchise

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links:<https://www.youtube.com/watch?v=Tzzfd6168jk&list=PLyqSpQzTE6M8EGZbmNUuUM7Vh2GkdbB1R>
https://www.youtube.com/watch?v=5RMqxtMwejM&list=PLyqSpQzTE6M9zMKj_PSm81k9U8NjaVJkR

Unit V

Small Scale Industry: Definition, Characteristics, types, role of SSI in Economic Development, steps to start SSI- Govt. Policy towards SSI, Institutional support- TECKSOK, KIADB, KSSIDC, KSIMC, DIC, NSIC, SIDBI, KSFC.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links:<https://www.nptel.ac.in/courses/110/105/110105067/>

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)
3. Management and Entrepreneurship by K. R. Phaneesh, Sudha Publications, Bangalore

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 functions for the given organization. (PO-6,8,9,10)
3. Analyze the advantages and potential drawbacks of Entrepreneurship. (PO-6,7,8)
4. Develop a basic business plan and analyze the benefits of buying Franchise. (PO-3,5,7,8,11)
5. Identify the various institutions that provide financial support to small scale industries. (PO-6,11)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	Marks	Course outcomes addressed
Internal test-I	30	CO1, CO2
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30marks.		
Other components		
Quiz	10	CO1, CO2,CO3
Assignment	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

PROCESS CONTROL	
Subject Code: CH62	Credits: 3:1:0
Pre requisites: Laplace Transforms, Process calculations	Contact Hours: 45L+30T+45S
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 and talk, 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 and talk, 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 and talk, 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 and talk, 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. Controller tuning Ziegler – Nichols rules. Cohen & Coon tuning method.

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

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

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO1, CO2, CO3, CO4, CO5
Quiz/Presentations	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

PHARMACEUTICAL TECHNOLOGY	
Subject Code: CHE631	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr. Ashwini Wali	

Course Content

Unit I

Drug Development and Synthetic Route Selection: 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 and talk, power point presentations
- Links: <https://www.youtube.com/watch?v=rUMC7c0ytoU>
https://www.youtube.com/watch?v=4m66uajU_Jg

Unit II

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

- Pedagogy: Chalk and talk, 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

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

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

Unit IV

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

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

Unit V

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

- Pedagogy: Chalk and talk, power point presentations
- Links: <https://www.youtube.com/watch?v=iQBv19WhP4o>
<https://www.youtube.com/watch?v=Z2Jy1SGyHE>

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, 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, PSO-1)
4. Understanding and apply the various processing and manufacturing techniques. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, PSO-1)
5. Conduct formulate a pure drug substance into a dosage form. (PO-1, 2, 3, 4, 5, 7, 8, 9, 11, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		

Assignment	10	CO1, CO2, CO3, CO4, CO5
Research paper	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

BIOFUELS	
Subject Code: CHE632	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Chemical Engineering Faculty	

Course Content

Unit I

Introduction: Fundamental concepts Introduction to understanding biofuels and bioenergy systems, 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

Chemically Produced Biofuels: Introduction; Biodiesel production process; Types of feedstocks and catalysts used for biodiesel production, Biodiesel from microalgae, Biodiesel economics.

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

Unit III

Biomass Derived Fuels: Types of biomass derived fuels and energy, Thermo-chemical and biochemical conversion of biomass to fuel, effect of different parameters on pyrolysis and gasification.

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

Advanced Biofuels: Cellulosic ethanol production: physical and chemical pre-treatment studies; Biohydrogen production and applications; Furfural production and applications.

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

Unit V

Environmental & Sustainability in Biofuels: 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. David M., Introduction to Biofuels, CRC Press, 2010, Taylor and Francis Group.

Reference Books:

1. Waste bio refinery, Thalleda, Basker, etal2021, 1st edition, Elsevier publications.
2. Hong zhang chan, Lingno cellulose bio refineries engineering, Elsevier 2015.

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, PSO-3)
2. Explain the importance of biodiesel production process. (PO-1, 6, 7, 8, 9, 10, PSO-3)
3. Explain the importance of biomass derived fuels; pyrolysis and gasification. (PO-1, 6, 7, 8, 9, 10, PSO-3)
4. Explain the significance of advanced biofuels. (PO- 1, 6, 7, 8, 9, 10, PSO-3)
5. Explain environmental aspects of biofuel. (PO- 1, 6, 7, 8, 9, 10, PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO1, CO2
Assignment /Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

ELECTROCHEMICAL TECHNOLOGY	
Subject Code: CHE633	Credits: 3:0:0
Pre requisites: Engineering Chemistry	Contact Hours: 45L+45S
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 and talk, 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

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

- Pedagogy: Chalk and talk, 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 Voltametric electro analysis, Polarography.

- Pedagogy: Chalk and talk, 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

Electrochemical Processes and Energy Storage Systems:

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

- Pedagogy: Chalk and talk, 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 and talk, 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. Elucidate different fundamental laws of electro chemical technology. (PO-1,2, PSO-1)
2. Derive different kinetic theories of electrode processes. (PO-1, 2, PSO-1)
3. Comprehend potentiometric and polarographic principles to practical systems. (PO-1, PSO-1)
4. Design a simple methodology for metals and alloys deposition on surfaces put into practice Primary, Secondary and Fuel Cells. (PO-1, 7,8, PSO-1)
5. Comprehend the principles of corrosion and its prevention to different environmental conditions in a chemical process industry. (PO-1, 2, 6,7,8, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Report	10	CO1, CO2, CO3
Case Study/Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

CHEMICAL PROCESS OPTIMIZATION	
Subject Code: CHE634	Credits: 3:0:0
Pre requisites: Engineering Mathematics IV	Contact Hours: 45L+45S
Course Coordinator: Dr. Alex Koshy	

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://nptel.ac.in/courses/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://nptel.ac.in/courses/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://nptel.ac.in/courses/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://nptel.ac.in/courses/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://nptel.ac.in/courses/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, PSO-2)
4. Optimize multivariable problems using numerical methods. (PO-1, 2, PSO-2)
5. Apply linear programming methods in optimization. (PO-1, 2, PSO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		

Assignments	10	CO1, CO2, CO3, CO4, CO5
Assignments /Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

PRINCIPLES OF FOOD PROCESSING AND PRESERVATION	
Subject Code: CHE635	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
Course Coordinator: Dr Rama Siva Kiran Reddy	

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 and talk, 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 and talk, 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 and talk, 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 and talk, 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 and talk, 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. Evaluate 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, 8, 11, PSO-1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Report	10	CO1, CO2, CO3
Case Study/Quiz	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

OPERATIONS RESEARCH	
Subject Code: CHE641	Credits: 3:0:0
Pre requisites: Engineering Mathematics I and II	Contact Hours: 45L+45S
Course Coordinator: Dr G M Madhu	

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)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3, CO4, CO5
Assignments /Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

INDUSTRIAL WASTE WATER TREATMENT	
Subject Code: CHE642	Credits: 3:0:0
Pre requisites: Engineering Chemistry & Environmental Studies	Contact Hours: 45L+45S
Course Coordinator: Dr Sagar J S	

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, 6, 7,8, PSO-1,3)
2. Design industrial waste waters treatment plants based on the type of waste water (PO-1, 2, 3, 6, 7,8, PSO-1,3)
3. Identify the type of waste water generated and develop the process methodology for treatment (PO-1, 2, 3, 6, 7,8, PSO-1,3)
4. Identify and Design the Biological Treatment methods in waste water plants. (PO-1, 2, 3, 6, 7,8, PSO-1,3)
5. Apply the waste water methodology in different chemical plants. (PO-1, 2, 3, 6, 7,8, PSO-1,3)

HAZARD ANALYSIS AND RISK MANAGEMENT	
Subject Code: CHE643	Credits: 3:0:0
Pre requisites: Nil	Contact Hours: 45L+45S
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://www.youtube.com/watch?v=Oa1WOxAx8lY>

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://www.youtube.com/watch?v=GeKBDv2lSfM&list=PLbRMhDVUMngdeZEnOQnRRWQAN-9bJ_cfo&index=2

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://www.youtube.com/watch?v=n1s1UB80JgA>
-

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://www.youtube.com/watch?v=n1xRXAkXwjE&list=PLbRMhDVUMn_gdeZEnOQnRRWQAN-9bJ_cfo

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. Comprehend hazards in chemical industries. (PO-1, 2, 3, 7, PSO, 1)
2. Elucidate 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)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Mini Project	10	CO1, CO2, CO3, CO4, CO5
Quiz/Presentations	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

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: 45L+45S
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: 45L+45S
Course Coordinator: Dr. Rajeswari M Kulkarni	

Course Content

Unit I

Introduction: Bioprocess engineering and technology. Role of a Chemical engineer in bioprocess industry. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Characteristics and control of microorganisms.

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 and talk, 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 and talk, 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 and talk, 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 and talk, 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 and talk, power point presentations
- Links: <https://archive.nptel.ac.in/courses/103/105/103105054/#>

Text Book:

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

Reference Books:

1. Pelczar, 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. Elucidate the basics of microbiology and role of Chemical Engineers in bioprocess industries. (PO-1, PSO-1)
2. Illustrate kinetic studies of enzymatic reactions and design processes. (PO-1, 2, 3, PSO-1)
3. Perform kinetic studies of enzymatic reactions in presence of inhibitors. (PO-1, 2, 3, PSO-1)

4. Summarize fermentation technology, operation and maintenance of equipment in industry. (PO-1, 2, PSO-1)
5. Analyze the kinetics of microbial growth and control of bioreactors. (PO-1, 2, 3, 6, 7, PSO-1).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3, CO4, CO5
Quiz/Research Paper	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

SIMULATION LABORATORY - I	
Subject Code: CHL65	Credits: 0:0:1
Pre requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. V.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 from benzene
 - e. Ethanol Amine from Ethylene oxide

Course Outcome (COs):

On successful completion of the course students will be able to

1. Simulate chemical unit operations using Aspen HYSYS (PO-2, 3, 5, 8, 9, 10, PSO-2)
2. Develop and optimize the chemical process flow diagram using ASPEN HYSYS. (PO-2, 3, 5, 8, 9, 10, PSO-2, 3)
3. Document and reporting of simulation results. (PO-2, 3, 5, 8, 9, 10, PSO-2, 3)

Reference Books:

1. Haydary, J. (2019). Chemical process design and simulation: Aspen Plus and Aspen Hysys applications. John Wiley & Sons.
2. Hanyak, M. E. (2013). Chemical Process Simulation and the Aspen HYSYS v8. 3 Software. Department of Chemical Engineering, Bucknell University.

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test	20	CO1, CO2, CO3
Other Components		
Conduction, Calculation, Record and Viva	30	CO1, CO2, CO3
Semester-End Examination (SEE)	50	CO1, CO2, CO3

PROCESS CONTROL LABORATORY	
Subject Code: CHL66	Credits: 0:0:1
Pre requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. D Jaya Prasanna Kumar	

Course Content

List of experiments:

1. Determine the time constant of the Thermometer for a given step input
2. Determine the time constant of Single tank for a given step input
3. Determine time constant of Non-Interacting Two Tanks for a given step input
4. Determine time constant of Interacting Two Tanks for a given step input
5. Determine the time constant of Single tank for a given impulse input
6. Determine time constant of Non-Interacting Two Tanks for a given impulse input
7. Determine time constant of Interacting Two Tanks for a given impulse input
8. Control the Level/Flow/Pressure/pH/Temperature control using P controller
9. Control the Level/Flow/Pressure/pH/Temperature control – PI controller
10. Control the Level/Flow/Pressure/pH/Temperature control – PD controller
11. Control the Level/Flow/Pressure/pH/Temperature control – PID controller
12. Determine the Valve characteristics of the control valve
13. To study the characteristics of the Flapper Nozzle System
14. To study the characteristics of the Valve Positioner.
15. To study the characteristics of U – Tube Manometer

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyze the dynamic behavior of systems for various types of inputs. (PO-1, 2 ,4, 5, 8, 9, 10, PSO-1,3)
2. Optimize controller performance for level, flow and pressure systems through parameter tuning (PO-1, 2 ,4, 5, 8, 9, 10, PSO-1,3)
3. Valve characteristics for their selection in process industries. (PO-1, 2 ,4, 5, 8, 9, 10, PSO-1,3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test	20	CO1, CO2, CO3
Other Components		
Conduction, Calculation, Record and Viva	30	CO1, CO2, CO3
Semester-End Examination (SEE)	50	CO1, CO2, CO3

INSTITUTIONAL OPEN ELECTIVE-I

SOLID WASTE MANAGEMENT	
Subject Code: CHOE01	Credits: 3:0:0
Pre requisites: Environmental Engineering	Contact Hours: 45L+45S
Course Coordinator: Dr. Koteswararao J and Dr. Sagar JS	

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview
- <https://www.youtube.com/watch?v=pGAouXqulNI&list=PLjl0eEOZe0IABNCeZd90uRerZu-M6HqwM>

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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview
- <https://www.youtube.com/watch?v=Nsi3R39V5q4&list=PLcwp2fRcIXJX8GJNev2Q818wW5qv-YdPE>

Unit III

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

- Pedagogy: Chalk and talk, 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 and talk, 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 and talk, power point presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ce66/preview
- <https://www.youtube.com/watch?v=HBkwTyBI75M>

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, 3, 4, 6, 8, PSO-1,2,3)
2. Understand the various functional element in solid waste management and perform calculations. (PO-1, 2, 3, 4, 6, 8, PSO-1,2,3)
3. Apply various processing techniques and suitable design considerations for land filling sites. (PO-1, 2, 3, 4, 6, 8, PSO-1,2,3)
4. Apply techniques of material recovery and energy recovery from solid waste. (PO-1, 2, 3, 4, 6, 8, PSO-1,2,3)

5. Develop a management plan for handling solid waste for various process industries and municipalities (PO-1, 2, 3, 4, 6, 8, PSO-1,2,3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignments	10	CO1, CO2, CO3
Assignments	10	CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MINI PROJECT (Experimental/Design)	
Subject Code: CHP67	Credits: 0:0:4
Pre requisites:	Contact Hours: 8
Course Coordinator: Chemical Engineering Faculty	

Course Content

The students shall work in groups of four to undertake experimental and/or analytical work related to the assigned problem statement under the guidance of the designated project supervisor. Each group must deliver two comprehensive presentations highlighting the progress and outcomes of their project work and submit the final project report at the end of the semester. The performance of the students are evaluated throughout the semester by the project guide and the Project Coordination Committee for the award of CIE marks, based on the rubrics defined by the committee. The final project report will be evaluated, and the students must undergo the prescribed examination at the end of the VI semester as part of the SEE.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply critical thinking and quantitative methods to devise innovative engineering solutions to the problems taken in project work. (PO-1,2,3,6,7,8,9,10,11, PSO-1,3)
2. Execute the protocols and perform experimental work with theoretical analysis. Demonstrate ethical integrity and honesty in professional practices. (PO-1,2,3,6,7,8,9,10,11, PSO-1,3)
3. Implement computational analysis and exhibit leadership and strategic vision to execute project objectives. (PO-1,2,3,6,7,8,9,10,11, PSO-1,2,3)
4. Collaborate effectively with diverse teams, leveraging strong interpersonal communication skills. Document precise project report including extensive literature review and present the work progress time to time. (PO-1,2,3,6,7,8,9,10,11, PSO-1,3)
5. Evaluate the sustainability and environmental impact of engineering solutions, ensuring positive societal outcomes. (PO-1,2,3,6,7,8,9,10,11, PSO-1,3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes attained
Presentation 1	20	CO1, CO2, CO5
Presentation 2	30	CO3, CO4, CO5
Semester-End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

TECHNICAL SKILL ENHANCEMENT COURSE	
Subject Code: CH68	Credits: 0:1:0
Pre requisites:	Contact Hours:30T
Course Coordinator: Industry Expert	
*Assessment is based on Continuous Internal Evaluation(CIE)	

Course Content

Industry expert lecture will be organized in specific areas to enhance knowledge and industrial exposure for benefit of students

Unit-1

Fundamentals of process simulation: Introduction, Architecture in process simulation, Industry perspectives, selection of thermodynamic model, Steady state and dynamic process simulation, controllers, control valve, control strategy of unit operations

Unit-2

Simulation using software: Unit operation models, Streams, Separator, Heater/Cooler, Heat Exchanger, Distillation Column (Shortcut/ Rigorous type), Liquid-Liquid Extraction, Reactors

Unit-3

Energy management: Various types of energy, Energy Security and Energy Conservation, Energy Conservation Act, Fundamentals of Energy Management and role of Engineers, Energy Audit in Industries, Data analysis and performance assessment, Sustainability and GHG/Carbon Accounting

Asset performance management

Assessment based on Case Studies and Group Activity