



RAMAIAH
Institute of Technology

CURRICULUM
Outcome Based Education
(Academic Year 2026 – 2027)

CHEMICAL ENGINEERING

III & IV Semester B. E

Batch: 2025

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 IICChE 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.

KNOWLEDGE AND ATTITUDE PROFILE (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behaviour and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

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 2025-29

Semester Course Category	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Applied Science Courses (ASC)	08	08	03	---	---	---	---	---	19
Engineering Science Courses(ESC/ PLC/ETC)	10	05	---	---	---	---	---	---	15
Humanities, Social Sciences and Management (HSMC)	01	02	---	---	03	---	03	---	09
Ability Enhancement Course (AEC)	01	01	01	01	01	---	---	---	05
Skill Development Course (SDC)	---	---	---	---	---	01	---	---	01
Universal Human Values (UHV)	---	---	02	---	---	---	---	---	02
Professional Core Course (PCC)/ Program Specific Course (PSC)	---	04	11	12	11	11	04	---	53
Integrated Professional Core Course (IPCC)	---	---	04	04	04	---	04	---	16
Professional Electives Courses - (PEC)	---	---	---	03	03	03	03	---	12
Open Elective Courses (OEC)	---	---	---	---	---	03	03	---	06

Internship (INT)	---	---	---	---	---	---	---	04	04
Mini Project/ Project Work(PW)	---	---	---	---	---	04	02	12	18
Non Credit Mandatory Courses (NCMC)	---	---	---	Yes	Yes	Yes	---	---	---
Total Credits	20	20	21	20	22	22	19	16	160
Skill lab	---	01	01	01	01	01	---	---	05

B.E.in Chemical Engineering
SCHEME OF TEACHING III SEMESTER Batch:2025

Sl. No.	Course Code	Course Name	Teaching Department	Category	Credits				Total contact hours/week			
					L	T	P	Total	L	T	P	S
1.	CH31	Integral Transforms and Complex Analysis	Mathematics Department	ASC	2	1	0	3	2	2	0	2
2.	CH32	Momentum Transfer	Chemical Engineering	PCC (IC)	3	0	1	4	3	0	2	3
3.	CH33	Chemical Process Calculations	Chemical Engineering	PCC	2	1	0	3	2	2	0	2
4.	CH34	Mechanical Operation	Chemical Engineering	PCC	3	0	0	3	3	0	0	3
5.	CH35	Technical Chemistry	Chemistry Department	PCC	3	0	0	3	3	0	0	3
6.	UHV36	Universal Human Values	Chemical Engineering	UHV	2	0	0	2	2	0	0	2
7.	CHAEC37	Ability Enhancement Course-III Environmental Life Cycle Assessment	Chemical Engineering	AEC	1	0	0	1	1	0	0	1
8.	CHL38	Technical Chemistry Lab	Chemistry Department	PCC	0	0	1	1	0	0	2	0
9.	CHL39	Mechanical Operation Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
Total					16	2	3	21	16	4	6	16
10	PE69	Physical Education							All students have to register compulsorily for any one of the courses with the concerned coordinator (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.			
	YO69	Yoga										
	NS69	NSS										
11	AM31	Additional Mathematics - I *	Mathematics		NCMC			0	0	0	0	--

12	CHSL2	Skill Lab - II		SDC	0	0	1	1	To be evaluated at the end of the semester but shall be reflected in the VIII semester grade card.
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NOTE: Minimum of 1 subject should have a Tutorial component of 1 Credit.

Nomenclature: **ASC:** Applied Science Course, **IC:** Integrated Course (Practical Integrated with Theory Course), **PCC:** Professional Core Course, **UHV:** Universal Human Value 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)**

PCC & ASC 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.

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

- Each theory credit corresponds to one contact hour per week, while each practical 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 for the theory component shall be conducted through two internal tests of 30 marks each. Each test shall consist of three questions, out of which 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 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 ten questions with internal choice (two questions per unit). Students shall answer any five full questions, selecting at least one question from each unit.
- However, questions from the practical component of the Integrated course may be included in the SEE question paper.

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.

UHV is a 2-credit course involving 2 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.

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.

The Non Credit Mandatory Course, Physical Education (Sport and Athletics)/Yoga/National Service Scheme (NSS):

1. Student shall select any one of the NCMC's namely, Physical Education (Sport and Athletics)/Yoga/NSS prescribed for four semesters and shall attend the course from the III semester to VI semester to complete all the formalities of the course and earn requisite CIE score. The Pass/Fail shall be reflected in the VI semester grade card.
2. The above mentioned NCMC's shall not be considered for vertical progression as well as for the calculation of SGPA/CGPA but completion of the courses shall be mandatory for the award of degree.
3. CIE marks will be allotted by the concerned course teacher based on attendance and performance in the practice sessions/field work every semester (III to VI) for 100 marks and the total 400 marks scored by the student are scaled down to 100 in the VI semester.
4. In case, any student fails to secure the minimum 40% of the prescribed marks, he/she shall be deemed to have secured 'F' grade.

*** Lateral Entry Students:**

The Non-Credit Mandatory Course, Additional Mathematics I: is prescribed for III Semester Lateral Entry Diploma students admitted to III Semester of BE Program. The student shall register for this course along with other III semester courses. The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. The CIE shall be evaluated for 100 marks. 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. In case student fails to register for the said course/ falls short of attendance, he/she will

repeat the course whenever it is offered next. Additional Mathematics I shall have CIE component only and **no SEE component**. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.

Skill Lab Course: is a 1-credit Lab 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 students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. The course shall be evaluated through Continuous Internal Evaluation (CIE) for 100 marks. The result of the course will be reflected in the Grade card of VIII semester.

Lateral Entry Students:

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.

B.E.in Chemical Engineering

SCHEME OF TEACHING IV SEMESTER Batch:2025

Sl. No.	Course Code	Course Name	Teaching Department	Category	Credits				Total contact hours/week			
					L	T	P	Total	L	T	P	S
1.	CH41	Chemical Reaction Engineering-I	Chemical Engineering	PCC(IC)	3	0	1	4	3	0	2	3
2.	CH42	Process Heat Transfer	Chemical Engineering	PCC	2	1	0	3	2	2	0	2
3.	CH43	Mass Transfer-I	Chemical Engineering	PCC	2	1	0	3	2	2	0	2
4.	CH44	Chemical Engineering Thermodynamics	Chemical Engineering	PCC	2	1	0	3	2	2	0	2
5.	CHE45X	Program Elective Course - I	Chemical Engineering	PEC	3	0	0	3	3	0	0	3
6.	CHAE46	Ability Enhancement Course-IV Industrial Pollution Control & Safety	Chemical Engineering	AEC	1	0	0	1	1	0	0	1
7.	CHL47	Pollution Control Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
8.	CHL48	Heat Transfer Lab	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
9.	CHL49	Process Equipment Drawing (AutoCAD)	Chemical Engineering	PCC	0	0	1	1	0	0	2	0
Total					13	3	4	20	13	6	8	13
10.	AM41	Additional Mathematics – II *	Mathematics Department	NCMC	0	0	0	0	---			
11.	CHSL3	Skill Lab - III		SDC	0	0	1	1	To be evaluated at the end of the semester but shall be reflected			

									in the VIII semester grade card.
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Program Elective Course- I

CHE451	Materials Science	CHE454	Probability, Statistics and Numerical Methods
CHE452	Electrochemical Technology	CHE455	Polymer Processing Technology
CHE453	Non-Conventional Energy Sources and Technology		

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)

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.

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.

*** Lateral Entry Students:**

The Non-Credit Mandatory Course, Additional Mathematics II: is prescribed for IV Semester Lateral Entry Diploma students admitted to III Semester of BE Program. The student shall register for this course along with other IV semester courses. The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. The CIE shall be evaluated for 100 marks. In case, any student fails to secure the minimum 40% of the prescribed CIE marks, he/she shall be deemed to have secured 'F' grade. In such a case, the student has to fulfil the requirements during subsequent semester/s to appear for CIE. In case student fails to register for the said course/ falls short of attendance, he/she will repeat the course whenever it is offered next. Additional Mathematics II shall have CIE component only and **no SEE component**. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.

Skill Lab Course: is a 1-credit Lab 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 students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. The course shall be evaluated through Continuous Internal Evaluation (CIE) for 100 marks. The result of the course will be reflected in the Grade card of VIII semester.

Lateral Entry Students:

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.

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.

III SEMESTER

Integral Transforms, Complex Analysis and Partial Differential Equations

Course Code: CH31	Credits: 2:1:0
Pre-requisites: Calculus	Contact Hours: 30L+30T+30S
Course coordinators: Dr. N L Ramesh	

Course Content

Unit I

Laplace Transforms: Definition, Transform of standard functions, Properties of Laplace transforms, Existence conditions, Transforms of derivatives, Integrals, Multiplication by t^n , Division by t , Evaluation of integrals by Laplace transforms and Transform of Periodic function.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105134>
<https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/59742/295>

Unit II

Application of Laplace Transform: Unit–step function, Unit–impulse function. Inverse transforms, Convolution Theorem, Solution of linear differential equations and Simultaneous linear differential equations using Laplace transforms. Engineering applications.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105134>
<https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/59742/295>

Unit III

Complex Variables - I: Functions of complex variables, Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Consequences of Cauchy-Riemann Equations, Construction of analytic functions. **Transformations:** Conformal

transformation, Discussion of the transformations $w = e^z$, $w = z^2$ and $w = z + \frac{a^2}{z}$, ($z \neq 0$), Bilinear transformations.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105134>
<https://nptel.ac.in/courses/111107119>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/619570/1030>
- <https://a.impartus.com/ilc/#/course/96127/452>

Unit IV

Complex Variables-II: Complex integration, Cauchy's theorem, Cauchy's integral formula, Taylor's & Laurent's series (statements only), Singularities, poles and residues, Cauchy residue theorem.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105134>
<https://nptel.ac.in/courses/111107119>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/619570/1030>
- <https://a.impartus.com/ilc/#/course/96127/452>

Unit V

Partial differential equations: Introduction to PDE, Solutions of partial differential equations – direct integration method, method of separation of variables.

Solution of PDE's using Finite difference method: Classification of second order PDE, Solution of one dimensional heat equation using Schmidt method, one dimensional wave equation using explicit method. Solution of two dimensional Laplace equation.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111101153>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/290290/703>
- <https://a.impartus.com/ilc/#/course/171951/703>

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, 2011/2015, published by Wiley.

2. B. S. Grewal, Higher Engineering Mathematics, 44th edition – 2017, Khanna Publishers.

References:

1. Glyn James, Advanced Modern Engineering Mathematics, Pearson Education, 4th edition, 2010.
2. Dennis G. Zill and Patric D. Shanahan, A First Course in Complex Analysis with Applications, Jones and Bartlett Publishers, 2nd edition, 2009.

Course Outcomes (COs):

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

1. To solve Laplace transforms of given function and understand their properties. (PO-1, 2 & PSO-1, 2)
2. Obtain inverse Laplace transforms and use it to solve system of ODE's. (PO-1, 2 & PSO-1, 2)
3. Examine and construct analytic functions. (PO-1, 2 & PSO-1, 2)
4. Classify singularities of complex functions and evaluate complex integrals. (PO-1, 2 & PSO-1, 2)
5. Find the solution of PDE's analytically and numerically. (PO-1, 2 & PSO-1, 2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes addressed
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		
Lab components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE) (Scaled to 50 Marks)	100	CO1, CO2, CO3, CO4, CO5

MOMENTUM TRANSFER	
Course Code: CH32	Credits: 3:0:1
Pre – requisites: Nil	Contact Hours: 45L+30P+45S
Course Coordinator: Dr. Archna	

Course Content

Unit I

Fluid Statics and its Application: Concepts of pressure, variation of pressure with height – hydrostatic equilibrium, barometric equation, measurement of fluid pressure – U tube differential and inverted manometers.

Newton’s law of viscosity, Newtonian and Non-Newtonian fluids, Reynolds number
Types of flow-laminar and turbulent flow. Boundary Layer.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://nptel.ac.in/courses/103104043>
- Laboratory session: Reynolds Experiment

Unit II

Basic Equations of Fluid Flow: Average velocity, mass velocity, continuity equation, Euler and Bernoulli’s equations, Modified equation for real fluids with correction factors. Pump work in Bernoulli’s equations.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.khanacademy.org/science/physics/fluids/fluid-dynamics/v/fluids-part-8>
- Laboratory session: Bernoulli’s experiment

Unit III

Transportation and Metering of Fluids: Pipes, fittings and valves, measurement of flow rates by orifice meter, Venturi meter, Rota-meter and Pitot tube. Flow through open Channels- weirs and notches. Performance and characteristics of pumps – positive displacement and centrifugal pumps.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: Centrifugal Pump <https://www.youtube.com/watch?v=8YDTgjkGraQ>
- Sectional View – Centrifugal Pump
<https://www.youtube.com/watch?v=omgfWh3Ny18>
- Flange Joint <https://www.youtube.com/watch?v=v00g-tf6zLg>
- Laboratory session: Venturimeter, Centrifugal pump

Unit IV

Flow of Incompressible Fluids: Laminar flow through circular and non-circular conduits. Hagen-Poiseuille equation, Newtonian liquids, turbulent flow in pipes and closed channels, friction factor chart. Friction from changes in velocity or direction. Flow in pipe/annulus fitting & joints.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=3fpCjUn-14>
- Laboratory session: Flow through a straight pipe, Losses across pipe fittings and joints

Unit V

Flow of Compressible Fluids: Continuity equation, Bernoulli's equation, Velocity of sound wave in a fluid, concept of Mach number, Stagnation properties, Area velocity relationship for compressible flow.

Dimensional Analysis: Dimensional homogeneity, Rayleigh and Buckingham- π method. Significance of different dimensionless numbers.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=QGVLPWq2qQ>
- <https://www.youtube.com/watch?v=2I6CceTV7Mc>

Text Books:

1. McCabe, W.L., Unit operations of Chemical Engineering, 5th Edition, McGraw Hill, New York, 1993.
2. Bansal, R.K., Fluid Mechanics and Hydraulic Machines, 7th Edition, Laxmi Publications, 2007.

Reference Books:

1. Coulson and Richardson J.F., Chemical Engineering Vol. 1, 3rd edn., Pergamon Press, 1991.
2. Badger, W.I. and Banchero, J.T., Introduction to Chemical Engineering, Tata McGraw Hill, New York, 1997.
3. Foust, A.S., Principles of Unit Operation, III Edition, John Wiley and Sons, New York, 1997.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyse different types of fluids and measure fluid pressure. (PO-1, 2, PSO-1)
2. Interrelate the different types of fluids and analyse the relationship between kinetic, potential and pressure energy in complex flow systems using Bernoulli's equation. (PO-1, 2, 4, 5, 9, PSO-1, 2, 3)
3. Interpret the types of pumps, transportation and metering devices for fluid handling. (PO-1,2, PSO-1, 3)
4. Analyse friction factor for different types of flow channels (PO-1, 2, 4,5,9 PSO-1, 2, 3)
5. Summarize the flow of compressible fluids and develop mathematical equations for adiabatic and isothermal flow conditions. Apply the dimensional method of analysis. (PO-1, 2, PSO-1, 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		
Lab experimental work & Record writing	15	CO1, CO2, CO3, CO4, CO5
Lab Test	05	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

CHEMICAL PROCESS CALCULATIONS	
Course Code: CH33	Credits: 2:1:0
Pre – requisites: Elements of Chemical Engineering	Contact Hours: 30L+30T+30S
Course Coordinator: Dr. J. Koteswara Rao	

Course Content

Unit I

Basic Chemical Calculations: Conversion of equations. Compositions of mixtures (solids, liquids and gases). **Vapor - Gas Concepts:** Vapor pressure concepts and calculations for miscible and immiscible systems.

Data Representation and analysis

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=4EWmB9JVcBo&list=PL23LJMmRTn8fwtijrPEgIbqZAaKCC3oEg&index=4>
<https://www.youtube.com/watch?v=X3LNoSydQc&list=PL23LJMmRTn8fwtijrPEgIbqZAaKCC3oEg&index=5>
<https://www.youtube.com/watch?v=bYW70nsfGc&list=PL23LJMmRTn8fwtijrPEgIbqZAaKCC3oEg&index=6>

Unit II

Humidity: Humidity related terms, humidity chart, and humidification and dehumidification operation.

Material Balance without Reaction: General material balance equation for steady and unsteady states. Typical Steady state material balances in mixing, evaporation, drying, distillation, absorption, extraction, crystallization and evaporation.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=s7J6R9wECh8>

Unit III

Steady State Material Balance with Reaction: Principles of stoichiometry, Concept of limiting and excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, Selectivity, related Problems – without reactions and with reactions. Material balances involving Bypass, Recycle and Purging.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=LtSA06dy5MY>

Unit IV

Fuels and Combustion: Ultimate and Proximate analysis of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, Air – fuel ratio calculations.

Energy Balance: Determination of ΔH_R at standard and elevated temperature. Theoretical and flame temperatures and adiabatic flame temperature.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=LR7npspe-RI>
- <https://nptel.ac.in/courses/112106299>
- <https://www.youtube.com/watch?v=B7KuoJn6bpg>

Unit V

Balance on multiple unit process:

Case study -1 on Multiple unit process (Extraction – Distillation Process)

Case study -2 on Multiple unit process (Evaporation - Crystallizer)

Text Books:

1. Hougen, O.A., Watson, K.M. and Ragatz, R.A., Chemical Process Principles Part –I, Material and Energy Balances, Second Edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall of India, New Delhi, 1997.
3. Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd Edition, 2005.

Reference Books:

1. Bhatt, B.L. and Vora, S.M., Stoichiometry (SI Units), Third Edition, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
2. N. Chopey, Handbook of Chemical Engineering Calculations, 4th Ed., Mc-Graw Hill, 2012.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply unit conversion techniques, composition of mixtures, vapour - gas laws, and graphical data analysis methods to solve fundamental chemical engineering problems. (PO: 1, 2 3, 11 and PSO: 1).

2. Perform humidity calculations and formulate material balances without reactions for unit operations such as mixing, drying, evaporation, distillation, absorption, extraction, and crystallization. (PO: 1, 2 3, 11 and PSO: 1).
3. Analyze and solve material balance problems involving chemical reactions by applying stoichiometric principles, conversion, yield, selectivity, recycle, bypass, and purge calculations. (PO: 1, 2 3, 11 and PSO: 1).
4. Evaluate combustion processes and energy requirements by performing fuel analysis, combustion calculations, heat of reaction computations, and flame temperature estimations. (PO: 1, 2 3, 11 and PSO: 1).
5. Develop comprehensive material and energy balance models for integrated chemical process systems involving multiple interconnected unit operations and industrial case studies. (PO: 1, 2 3, 11 and 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/Mini Project	10	CO1, CO2, CO3, CO4, CO5
Assignment/Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MECHANICAL OPERATIONS	
Course Code: CH34	Credits: 3:0:0
Pre – requisites: Engineering Mathematics	Contact Hours: 45L+45S
Course Coordinator: Dr. Sagar JS	

Course Content

Unit I

Particle Technology: Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, mixed particles size analysis, screens – ideal and actual screens, Tyler series, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture, standard screens industrial screening equipment, motion of screen, grizzly, gyratory screen, vibrating screen, trommels.

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- NPTEL: Mechanical Operations by Prof. Shabina Khanam
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>

Unit II

Size Reduction: Introduction – types of forces used for comminution, criteria for comminution, characteristics of comminuted products, laws of size reduction, work index, energy utilization, methods of operating crushers – free crushing, choke feeding, open circuit grinding, closed circuit grinding, wet and dry grinding.

Equipment for size reduction: Blake jaw crusher, gyratory crusher, smooth roll crusher, attrition mill, ball mill, critical speed of ball mill, ultra-fine grinders fluid energy mill, cutters – knife cutter.

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- NPTEL: Mechanical Operations by Prof. Shabina Khanam
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>

Unit III

Flow of Fluid Past Immersed Bodies: Drag, drag coefficient, pressure drop – Kozeny – Carman equation, Blake- Plummer, Ergun equation, fluidization, conditions for fluidization, minimum fluidization velocity, types of fluidization, application of fluidization.

Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field,

terminal velocity, drag coefficient, motion of spherical particles in Stokes region, Newton's region and intermediate region, criterion for settling regime, hindered settling

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- NPTEL: Mechanical Operations by Prof. Shabina Khanam
- Impartus recording: <http://a.impartus.com/ilc/#!/course/81470/295>

Unit IV

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener, Coe and Clevenger theory, Kynch theory, thickener design, determination of thickener area.

Filtration: Introduction, classification of filtration, cake filtration, clarification, batch and continuous filtration, pressure and vacuum filtration, constant rate filtration and cake filtration, characteristics of filter media, industrial filters, filter press, rotary drum filter, bag filter, centrifugal filtration – suspended batch centrifuge, filter aids, application of filter aids, principles of cake filtration

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- NPTEL: Mechanical Operations by Prof. Shabina Khanam
- Impartus recording: <http://a.impartus.com/ilc/#!/course/81470/295>

Unit V

Agitation and Mixing: Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and Power calculation

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- NPTEL: Mechanical Operations by Prof. Shabina Khanam
- Impartus recording: <http://a.impartus.com/ilc/#!/course/81470/295>

Text Books:

1. McCabe W.L., Unit Operation of Chemical Engineering, V Edition, McGraw Hill International, Singapore, 2000.
2. Badger, W.L. and Banchero J.T., Introduction to Chemical Engineering, III Edition, McGraw Hill International, Singapore, 1999.
3. Coulson, J.M. and Richardson, J.F., Chemical Engineering Vol.2, 4, Particle Technology and Separation Process, 1998.

Reference Books:

1. Brown G., Unit Operation, I Edition, CBS Publishers, New Delhi, 1995.
2. Perry, R and Green, W.D., Perry's Chemical Engineering Hand book, VII Edition, McGraw Hill International Edition, New York, 2000.
3. Foust, A.S. *et.al*, Principles of Unit Operation, III Edition, John Wiley and Sons, New York, 1997.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyse particle characteristics, particle-size distribution, and screening operations to evaluate the performance and suitability of industrial screening equipment. (PO-1,2,3,8,11, PSO-1,3)
2. Analyse size reduction principles, energy requirements, and operating conditions to evaluate the performance and suitability of crushers, grinders, and ultrafine grinding equipment. (PO-1,2,3,8,11, PSO-1,3)
3. Determine the flow behaviour and motion of particles through fluids to determine drag, pressure drop, fluidization characteristics, and particle settling performance under different flow regimes. (PO-1,2, 3, 8, 11, PSO-1, 2, 3)
4. Interpret sedimentation and filtration processes to determine equipment design parameters and evaluate the performance and suitability of industrial solid–liquid separation equipment. (PO-1,2,3,5,8,11, PSO-1, 3)
5. Study about the agitation and mixing systems to evaluate flow patterns, impeller performance, and power requirements for effective mixing in process vessels. (PO-1,2,3,5,8,11, PSO-1, 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
Quiz/Surprise test	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

TECHNICAL CHEMISTRY	
Course Code: CH35	Credits: 3:0:0
Pre – requisites: CYM12	Contact Hours: 45L+45S
Course Coordinator: Dr. Nagaraju Kottam & Dr. Sharanabasappa Patil	

Course Content

Unit I

Kinetics of reactions: Determination of order, Rate equations for second order reactions, Theory of reaction rates-Arrhenius theory. Transition state theory of reaction rates, activation energy; kinetics of complex reactions–study of kinetics of reaction between hydrogen and bromine. Numericals.

Adsorption: Adsorption of gases on solids, Factors affecting adsorption, Different types of adsorption isotherms, Freundlich and Langmuir theories of adsorption, B.E.T. Theory of adsorption of gases.

Catalysis: characteristics, types, adsorption theory of catalysis, promoters, poisons. Industrial applications of catalysis (mention few examples like zeolites, oxides etc., related to adsorption and catalysis).

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/104106089>

Unit II

Properties of liquids: Physical properties and determination-viscosity, surface tension. Definition and significance of molar refraction and dielectric constant.

Colligative properties: Lowering of vapour pressure – Raoult’s law – Determination of M.W. Elevation of B.P Depression of freezing point determination of M.W, Osmotic pressure-determination of molecular weight and experimental measurements. Isotonic solutions and abnormal M.W.

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- Links: <https://openstax.org/books/chemistry-2e/pages/11-4-colligative-properties>

Unit III

Basic Principles of Organic Chemistry – Introduction, Homolytic and Heterolytic cleavages. Concept of reactive intermediates: free radicals Carbocations, Carbanions-Structure, stability and their reactivity. Types of reactions (addition reactions Elimination and substitution reactions). Review of electron displacement of covalent bond. Inductive and resonance effects; Mechanism of nucleophilic substitution (SN1 and SN2) in alkyl halides; Mechanistic concept of elimination reactions (E1 and E2).

Basics of stereochemistry: Isomerism- Structural, chain, positional, functional, metamerism, tautomerism and ring-chain isomerism. Stereo isomerism-cis-trans isomerism, optical activity of organic compounds, optical isomerism.

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/104106119>

Unit IV

Industrially Important Organic reactions: Beckmann Rearrangement, Perkin reaction, Hofmann rearrangement, Reamer-Tiemann reaction, Cannizzaro reaction, Skrap synthesis, Diels-Alder reaction, Aldol condensation.

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/104105462>
https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cy64

Unit V

Organic Materials of industrial importance: Soaps and detergents –Types of soaps - Liquid soap, Toilet soaps-opaque and transparent; Mechanism of cleansing action of soap; Synthetic detergents– Ionic detergents-anionic and cationic.

Classification and structure of drugs: Study of the following drugs with reference to structure: Antipyretics-Paracetamol, Anti-inflammatory drugs - Ibuprofen, Antibiotics, Anti-malarial drugs, Anti-cancer drugs, Anti-hypertensive drugs.

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

Text Books:

1. Morrison B.R. and Boyd L.L., Organic Chemistry 7th Edition, ELBS, New Delhi, 2011.
2. B.R. Puri, L.R. Sharma & Pathania, M.S., Principles of Physical Chemistry, 47th Ed., S. Nagin chand & Co., 2017.
3. House, H.O., Modern synthetic reactions, ULBS Publishers, New Delhi. 2nd Revised edition. Import 1972.
4. Bahl, A. and Bahl B.S., A Text Book of Organic Chemistry, 15th Edition. S. Chand and & Co, New Delhi, 1998.

Reference Books:

1. Sykes Peter, Organic Reactions Mechanism, 6th edition, ULBS Publishers, and New Delhi. 2003
2. Finar, Organic Chemistry Vol I & II, 6th Edition, ULBS Publishers, New Delhi. 1973
3. Sharma B.K., Industrial Chemistry, 11TH edition, Chand S, and Co. New Delhi, 2001.
4. Tiwari Melhotra and Vishnoi, Organic Chemistry, 7th Edition, Chand S. and Co. New Delhi, 1996.
5. Bikerman, J.J., Surface Chemistry: Theory and Applications, 2nd edition, Academic press, New York, 2013.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain catalytic reactions, the types of adsorption and applications in industry. (PO-1, 2, 3, 7, PSO-1)
2. Explain the effects of solutes on boiling point, freezing point, and osmotic pressure and to calculate the molecular weight of the unknown solute using freezing point depression. (PO-1, 2, 7, PSO-1)
3. Write reaction mechanisms in various types of reactions and their applications in relevant industries. (PO-1, 2, 3, 7, PSO-1)
4. Identify the different organic reactions using the various industries in the manufacture of drugs and organic compounds. (PO-1, 2, 3, 7, PSO-1)
5. Explain manufacture of soap and detergents, and their cleaning action mechanism. (PO-1,2,7, 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/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

UNIVERSAL HUMAN VALUES	
Course Code: UHV36	Credits: 2:0:0
Pre – requisites: Nil	Contact Hours: 30L+30S
Course Coordinator: Dr. Ashwini Wali	

Course Content

Unit I

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Understanding the need, basic guidelines, content and process for Value Education
2. Self-Exploration–what is it? - its content and process; ‘Natural Acceptance’ and Experiential Validation- as the mechanism for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfill the above human aspirations: understanding and living in harmony at various levels
 - Pedagogy / Course delivery tools: Chalk and talk, Power point presentation, Videos.
 - Lab component / Practical Topics: Survey/polls for self-exploration
 - Links: Holistic Development and Role of Education <https://youtu.be/sGZtTPe-lhQ>

Unit II

Understanding Harmony in the Human Being - Harmony in Myself!

- Understanding human being as a co-existence of the sentient ‘I’ and the material ‘Body’
- Understanding the needs of Self (‘I’) and ‘Body’ - *Sukh* and *Suvidha*
- Understanding the Body as an instrument of ‘I’ (I being the doer, seer and enjoyer)
- Understanding the characteristics and activities of ‘I’ and harmony in ‘I’

Understanding the harmony of I with the Body: *Sanyam* and *Swasthya*; correct appraisal of Physical needs, meaning of Prosperity in detail

- Programs to ensure *Sanyam* and *Swasthya*

Practice Exercises and Case Studies will be taken up in Practice Sessions.

- Pedagogy / Course delivery tools: Chalk and talk, Power point presentation, Videos.
- Lab component / Practical Topics: Survey/polls for self-exploration
- Links: Harmony in Human Being- Self and Body
<https://youtu.be/0ERSMkRPQBM>
- Links: Harmony in Human Being- Self <https://youtu.be/83oGJ4oDeIg>
- Links: Harmony between Self and Body Prosperity
https://youtu.be/aJ_BU2OgpKs

Unit III

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship

1. Understanding Harmony in the family – the basic unit of human interaction
2. Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti;
3. Trust (Vishwas) and Respect (Samman) as the foundational values of relationship
4. Understanding the meaning of Vishwas; Difference between intention and competence
5. Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship
6. Understanding the harmony in the society (society being an extension of family):
7. Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals
8. Visualizing a universal harmonious order in society- Undivided Society (Akhand Samaj), Universal Order (Sarvabhaum Vyawastha)- from family to world family!

Practice Exercises and Case Studies will be taken up in Practice Sessions.

- Pedagogy / Course delivery tools: Chalk and talk, Power point presentation, Videos.
- Lab component / Practical Topics: Survey/polls for self-exploration
- Links: Harmony in Family- Trust <https://youtu.be/F2KVVW4WNnS8>

- Links: Harmony in family- Respect https://youtu.be/iLqNRPuv0_8
- Links: Harmony in family- Other Feeling Justice <https://youtu.be/TcYJB7reKnM>
- Links: Harmony in the Society <https://youtu.be/BkWgFinrnPw>

Unit IV

Understanding Harmony in the Nature and Existence - Whole existence as Co-existence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature
3. Understanding Existence as Co-existence (*Sah-astitva*) of mutually interacting units in all-pervasive space
4. Holistic perception of harmony at all levels of existence

Practice Exercises and Case Studies will be taken up in Practice Sessions.

- Pedagogy / Course delivery tools: Chalk and talk, Power point presentation, Videos.
- Lab component / Practical Topics: Survey/polls for self-exploration
- Links: Harmony in Nature https://youtu.be/K1Jpd_ojydw
- Links: Harmony in Existence https://youtu.be/mormUeZ_RUE

Unit V

Implications of the above Holistic Understanding of Harmony on Professional Ethics

- Natural acceptance of human values
- Definitiveness of Ethical Human Conduct
- Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
- Competence in professional ethics:
 - a. Ability to utilize the professional competence for augmenting universal human order
 - b. Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems,
 - c. Ability to identify and develop appropriate technologies and management patterns for above production systems.

- Case studies of typical holistic technologies, management models and production systems
- Strategy for transition from the present state to Universal Human Order:
 - a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
 - b. At the level of society: as mutually enriching institutions and organizations

Suggested Learning Resources:

- Pedagogy / Course delivery tools: Chalk and talk, Power point presentation, Videos.
- Lab component / Practical Topics: Survey/polls for self-exploration

Text Books:

1. **R.R Gaur, R Sangal, G P Bagaria**, A foundation course in Human Values and professional Ethics, Excel books, New Delhi, 2010, ISBN 978-8-174-46781-2

Reference Books:

1. Indian Ethos and Modern Management, **B L Bajpai**, New Royal Book Co., Lucknow. Reprinted 2008. 2004
2. Science and Humanism, **PL Dhar, RR Gaur** Commonwealth Publishers, 1990.
3. How the Other Half Dies, **Sussan George**, Penguin Press, Reprinted 1991
4. , Energy & Equity, **Ivan Illich**, The Trinity Press, Worcester, and HarperCollins, USA
5. limits to Growth, **Donella H. Meadows, Dennis L. Meadows, Jorgen Randers**, William W. Behrens III, Club of Rome's Report, Universe Books.
6. How to practice Natural Farming, **Subhas Palekar**, Pracheen(Vaidik) Krishi Tantra Shodh, Amravati.
7. Jeevan Vidya ek Parichay, **A Nagraj**, Divya path Sansthan, Amarkantak. 1998.
8. Small is Beautiful: a study of economics as if people mattered, **E.F. Schumacher**, Blond & Briggs, Britain.
9. Human Values, **A.N. Tripathy**, New Age International Publishers, 2003.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw
2. <https://www.youtube.com/watch?v=P4vjfE-YnVk&list=PLWDeKF97v9SP7wSlapZcQRrT7OH0ZIGC4>
3. **Course handouts:**
https://drive.google.com/drive/folders/1zioX_4L2fCNX4Agw282PN86pcZZT3Osr?usp=sharing
4. **Presentation slides:**
https://drive.google.com/drive/folders/1rMUKh1s0HPRBlpp_b1mpS-duNRcwS6YH?usp=sharing

Course Outcomes (COs):

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

1. Apprehend the need of Value Education over Human aspirations (PO-6)
2. Assimilate Harmony over the physical needs and to overcome the self- needs for a prosperous life. (PO-6)
3. Recognize the need of Harmony in the Family and Society for a better World. (PO-6)
4. Explain the need of mutual understanding for Holistic Harmony in all the Levels of Human Existence. (PO-6)
5. Explain the Holistic understanding of Harmony and Professional Ethics at Individual Level and Society. (PO-6,8)

Continuous Internal Evaluation (CIE)		
Assessment Tool	Marks	Course outcomes addressed
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks.		
Other components		
• Assignment • Quiz • Presentation • Model / mini project	20 (10 + 10)	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

ABILITY ENHANCEMENT COURSE – III ENVIRONMENTAL LIFE CYCLE ASSESSMENT

Course Code: CHAEC37	Credits: 1:0:0
Pre – requisites: Nil	Contact Hours: 15L+15S
Course Coordinator: Dr. Rama Sivakiran Reddy	

Course Content

Unit I

Introduction to Life Cycle Assessment

Sustainability, Green Technology, Green Principles, Historical Dates of LCA Development, ISO 14000 Standards

- Pedagogy/Course delivery tools: Chalk & talk and Power point presentation
- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
www.youtube.com/watch?v=VNgtajZVAKE

Unit II

Phases in Life Cycle Assessment

Definition, performing an LCA, Environmental Tools, Goals, Scope and Definition, Functional Unit and Reference Flow, Examples, System Definition, System Boundaries

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
<https://www.youtube.com/watch?v=VNgtajZVAKE>

Unit III

Inventory Analysis

Inventory Analysis, Process-Based Calculation of the Inventory, Examples, Inventory Databases, Case Studies Pedagogy/Course delivery tools: Chalk and talk and Power point presentation.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
<https://www.youtube.com/watch?v=VNgtajZVAKE>

Unit IV

Life Cycle Impact Assessment

Life Cycle Impact Assessment, Principles of Impact Assessment, Methodological Framework: Midpoint and Damage Categories, Examples and Case Studies. LCA Data interpretation, Identification of Action Priorities, Examples and Case Studies

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation

- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
<https://www.youtube.com/watch?v=VNgtajZVAKE>

Unit V

Practical Implementation of Life Cycle Assessment

Life Cycle Assessment using software tools (Open LCA), Case Studies and Examples
Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
<https://www.youtube.com/watch?v=VNgtajZVAKE>

Text Books:

1. Olivier Jolliet, Myriam Saade-Sbeih, Shanna Shaked, Alexandre Jolliet, Pierre Crettaz (2016) Environmental Life Cycle Assessment 1st Edition, CRC Press, USA

Reference Books:

1. Guinée, J. B. (Ed.). (2002). Handbook on life cycle assessment: operational guide to the ISO standards (Vol. 7). Springer Science & Business Media.

Web links and Video Lectures (e-Resources):

1. NPTEL Course: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
2. **LCA Open Source Software (Open LCA):** <https://www.openlca.org>
3. **LCA Free Databases:** <https://nexus.openlca.org>

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the Green Principles and Sustainable Designs. (PO-1, 7, 12 PSO-1)
2. Explain Four Phases of Life Cycle Assessment. (PO-1,7,12, PSO-1)
3. Perform Inventory Analysis for Industries (PO-1,2,3, 5,7,12, PSO-1)
4. Perform Impact Assessment and LCA Data Interpretation (PO-1,2,3,5, 7, PSO-1)
5. Able to perform LCA Analysis using Software tools (PO-1,2,3, 5, 7, PSO-1, PSO-2)

TECHNICAL CHEMISTRY LAB	
Course Code: CHL38	Credits: 0:0:1
Pre – requisites: CYL17/27	Contact Hours: 30P
Course Coordinator: Dr. Sharanabasappa Patil & Dr. Nagaraju Kottam	

Course Content

1. Determination of partition coefficient of iodine between water and carbon tetrachloride.
2. Study of Kinetics of the reaction between $K_2S_2O_8$ and KI.
3. Determination of critical solution temperature of phenol-water system.
4. Determination of nickel as nickel dimethyl glyoximate gravimetrically (after separating Iron) in the given stainless steel solution.
5. Determination of iron as ferric oxide gravimetrically (after separating copper) in the given Chalcopyrite ore solution.
6. Determination of % composition of binary mixture using Ostwald's viscometer.
7. Precipitation titration between Lithium Sulphate and Barium Chloride by conductometry.
8. Preparation of Aspirin.
9. Thin layer Chromatography.
10. Determination of acid value, iodine value and saponification value of the given sample of oil.
11. Flame photometric determination of potassium / calcium in the given test solution.
12. Preparation of acetanilide by acetylation of aniline using acetic anhydride.
13. Estimation of carboxylic acid by Iodometric method.

Reference Books:

1. Arthur, I. Vogel's Qualitative Inorganic analysis including elementary instrumental analysis, ELBS, Longmann group, 5th Edition, 1989.
2. Clair N. Sawyer and Perry L, McCarty, Chemistry for Environmental Engineering, Third Edition, McGraw-Hill Book Company, New York, 1978.
3. Lab Manual: 2021-22

Course Outcomes (COs):

On successful completion of this course students will understand

1. Determination of chloride, nickel and iron in samples (PO-1,2, PSO-1,3)
2. Preparation of organic compounds, TLC and analysis of oils and fats (PO-1,2, PSO-1,3)
3. Effect of salt on CST and kinetics of the reaction (PO-1, 2, 3, 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

MECHANICAL OPERATION LAB	
Course Code: CHL39	Credits: 0:0:1
Pre – requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. Sagar J S	

Course Content:

1. To find the different average particle diameters of the given size distribution by sieve analysis.
2. To determine the specific surface area and number of particles per unit mass of the size distribution by differential and cumulative analysis using analytical and graphical methods given the shape factor and density.
3. To find the effectiveness factor of the given screen
4. To determine the constants of crushing laws and to find the work index using drop weight crusher.
5. To determine the constants of crushing laws and to find the work index by crushing the given feed in a Jaw Crusher.
6. To grind the given material in the ball mill and determine the increase in specific surface area.
7. To determine the average particle size of the given sample of CaCO_3 powder by ICI sedimentation method both analytically and graphically.
8. To determine the surface area of the given sample of powder by the air permeability apparatus.
9. To determine the minimum cross sectional area of a continuous thickener by conducting a single batch sedimentation test.
10. To find the specific cake resistance of cake (α) and filter medium resistance (R_m) for filtration through a plate and frame filter press.
11. To determine the specific cake resistance (α) and the filter medium resistance by processing a solid-liquid slurry in a leaf filter.
12. To determine the drying rate characteristics of wet granular or solid materials in a rotary drum drier.
13. To determine the drying rate characteristics of wet granular or solid materials in a tray drier.
14. To determine the particle size distribution of a powder sample using beaker decantation.

Course Outcomes: On successful completion of the course students will be able to

1. Perform particle size analysis. (PO-1,3, PSO-1,2)
2. Evaluate performance of size reduction and filtration equipment.
(PO-1,3, PSO-1,2)
3. Suggest their applications. (PO-1,3, PSO-1,2)

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

PHYSICAL EDUCATION	
Course Code: PE69	Credits: NCMC
Pre – requisites: Nil	
Course Coordinator: Dr. Kiran Kumar H K	

Course Content

Course Learning Objectives:

1. To introduce students to the importance of physical fitness for success in any career.
2. To instill in them concepts of team spirit and team building
3. To develop positive thinking, goal setting, and decision-making abilities under duress.
4. To harness values and skills like leadership, communication, and sacrifice.
5. To inculcate in students, the ability to handle success and failures with equanimity.

Selection Process: A Student shall select any one of the following Sports based on his/her interest and the facility available. The details **of Sports Facilities available (both indoor and outdoor) at the institute campus** are as below:

Outdoor Games		Indoor Games		Athletics	
Games	No. of Students	Games	No. of Students	Events	No. of Students
Volleyball	12 x 4 = 48	Badminton	30	Sprint - 100mt, 200mt, 400mt	60
Basketball	12 x 4 = 48	Table Tennis	30	Middle distance running – 800mt, 1,500mt	
Kabaddi	12 x 4 = 48	Chess	30	Long distance running 5,000mt, 10,000mt	
Kho Kho	12 x 4 = 48	Weight Training [Gym]	35	Jumping Events – Long Jump Triple Jump High Jump	30
Throw ball	12 x 4 = 48			Throwing Events Shot Put Discuss Javelin	30
Football	16 x 4 = 64	Note: Students should bring their own sports attires			
Hockey	16 x 4 = 64				
Cricket	16 x 4 = 64				

Contact Sessions: A student shall abide by the following during the sessions scheduled in the semester.

Session 1

Fundamentals of Physical Education, value addition to personality through fitness education, discipline and team building activities, Orientation towards particular sports and skill training

Session 2

Formation of teams based on student's orientation and preference. Team practice and skill enhancement.

Session 3

Conduction of matches in all sporting events registered by Students. Evaluation of each student shall be based on their performance either in team or individual. The student representing the Institute at University/State/National/International Level will be awarded additional marks during evaluation.

Course Outcomes (COs):

1. Develop interest and skill in playing particular sports.
2. Understand the process of organizing sporting events.
3. Appreciate the role of fitness for a better lifestyle.
4. Derive lessons from sports activities for effective planning and discipline in Life.
5. Analyze situations and optimize end results.

Course Assessment & Evaluation:

1. A committee consisting of Sports Director and Coaches of respective Sports will be formed to observe and evaluate the students for CIE in each semester.
2. Students shall follow the schedules, rules and regulations as prescribed by the Committee.
3. Students shall mandatorily have 85% attendance to be eligible for evaluation.
4. All the Sessions and evaluation process will be common for all semesters of the academic year.
5. The final result will be reflected on the grade card of 6th Semester.
6. The final marks shall be calculated after scaling down CIE to 50 marks & combining with 50 marks for SEE.

YOGA	
Course Code: YO69	Credits: NCMC
Pre – requisites: Nil	
Course Coordinator: Dr. Hari Chandra B P & Dr. Parimala P	

Course Content

Course Learning Objectives:

1. To introduce to the students, the fundamental theoretical aspects of yoga.
2. To inculcate in students a habit of practicing yoga.
3. To be able to demonstrate basic yoga asanas.
4. To be able to practice fundamental breathing practices and mudras.
5. To understand the relevance of yoga and research in modern times.

Introduction: Definition of yoga, benefits, astangas of yoga, Relevance of yoga and yoga-research in modern times.

Asanas: Kriyathmakachalanas, Suryanamaskar, Superbrain yoga, Vrikshasana, Trikonasana, Veerabhadrasana, Paschimotanasana, Purvothanasana, Bharadwajasana, Amruthasana, Parivruttha Trikonasana, Parsvakonasana, Ustrasana, Padmasana, Jaaanushirshasana, Navasana, Ardachakrasana, Ardhatichakrasana, Jataraparivarthanasana, Sethubandasana, Sarvangasana, Mathyasana, Dhanurasana, Shirshasana. **Pranayamas:** Anuloma-Viloma, Suryanuloma, Chandranuloma, Brahmari, Suryanbedhana, Chandrabedhana, Sheetali, Seethkari, Sadantha, bastrika.

Mudras: Chinmudra-Jnanamudra, Praana mudra, panchaprana mudras, panchabhoota mudras, Pruthvi mudra, Shoonya mudra, Surya mudra, Jalodharanashaka mudra, Kundalini mudra, shoonyaavaayu mudra, shakti mudra, sandhi mudra, vajra mudra and garuda mudra.

Course Outcomes (COs):

At the end of the course, a student will

1. Understand the fundamental and theoretical aspects of yoga.
2. Develop a habit of practicing yoga.
3. Demonstrate basic yoga asanas.
4. Demonstrate fundamental breathing practices.
5. Understand the relevance of yoga and its research in modern times.

Reference Books:

1. Light on yoga, B K S Iyengar, Publisher -Thorsons, UK, 2006

2. Light on pranayama, B K S Iyengar, Publisher - Element; First Edition
3. The Essential Yoga Mudras for Healing, Dr. Aasoori K. Rangaraja Iyengar, Saranga Publishing; First Edition 2021

Pedagogy:

Chalk and talk, demonstration, videos, ppt.

Contact Sessions:

There would be one introduction class, and five contact classes in each semester.

The candidates shall practice yoga on a daily basis, or in the worst case on alternate days at their place of residence and maintain a short diary in the format provided by yoga teacher. The same shall be brought to the classes.

Online Reference Sources:

- Yoga for beginners part 1: <https://www.youtube.com/watch?v=VwPeThpwfWI>
- Yoga for beginners part 2: https://www.youtube.com/watch?v=s_pnJTcOp8A
- Suryanamaskar: <https://www.youtube.com/watch?v=nUdlucNd6go&t=133s>
- Yoga for anxiety and stress: https://www.youtube.com/watch?v=hJbRpHZr_d0
- Common yoga protocol: https://www.youtube.com/watch?v=Av5ib_XRKT4
- Relevance of yoga in modern times: www.youtube.com/watch?v=HUzBCts7BTo

Course Assessment and Evaluation:

1. A committee consisting of Yoga Instructors will be formed to observe and evaluate the students for CIE in each semester.
2. Students shall follow the schedules, rules, and regulations as prescribed by the Committee.
3. Students shall mandatorily have 85% attendance to be eligible for evaluation.
4. All the Sessions and evaluation processes will be common for all semesters of the academic year.
5. The final result will be reflected on the grade card of 6th Semester.
6. The final marks shall be calculated after scaling down CIE to 50 marks & combining it with 50 marks for SEE.

Scheme of SEE

Practical Demonstration	30 marks
Write-up	10 marks
Viva	10 marks
Total	50 marks

NATIONAL SERVICE SCHEME	
Course Code: NS69	Credits: NCMC
Pre – requisites: Nil	
Course Coordinator: Dr. Puttabore Gowda & Dr. Siddaraju C	

Course Content

Course Learning Objectives:

1. To introduce students to the importance of national service
2. To harness values and skills like leadership, teamwork and sacrifice.
3. To serve society through educational services and health
4. To work towards rural and local development through technological services
5. To inculcate in students, the ability to handle socially relevant projects.

Students shall involve in activities related to national and regional technical and non-technical services, as listed below.

- Serving society by bringing awareness on education and cleanliness.
- Blood donation camps
- Developing technologies for rural masses.
- Conduction and participation in camps for a social cause.
- Educating towards health and well-being of individuals/society.
- Cultural and educational programs for society.
- Contributing towards the improvement of civil services and bringing certain shortcomings to the notice of higher authorities for suitable remedial actions.
- Contribution towards traffic management and other public services.
- Clean up and development of water sources around public places.
- Services during a disaster or other needy situations.
- Camps for the rejuvenation of lakes and water bodies.
- Serving nature and agriculture.
- Awareness programs on health and food adulteration.
- Presenting papers/talks in various fora on the above topics.
- Developing technologies for rural masses beyond academic requirements.
- Plantation programs.
- Conducting programs for self-sustainability, and human and national development.

- Contribution towards orphans and challenged individuals through well-recognized organizations.
- Carrying out designated activities in villages.
- Development and implementation of strategies for solid waste, E-waste etc.
- Education towards pollution control and traffic management.
- Production of documentaries and short films/videos for motivating people on any of the above causes.

Course Outcomes (COs):

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

1. Understand the importance of national service.
2. Gain skills like leadership and teamwork.
3. Volunteer towards educational services and health.
4. Contribute to rural and local development through technical services.
5. Comprehend socially relevant projects

Contact Sessions:

The students shall attend the review and contact sessions as scheduled by the course coordinator.

Course Assessment and Evaluation:

1. The candidates shall maintain a record of activities in a Diary, and get them endorsed during the contact sessions at least 3 times in a semester.
2. A detailed project report should be submitted during the last fortnight of the semester.
3. Evaluation will be done during each semester based on the nature of the contribution.
4. The final marks shall be calculated after scaling down CIE to 50 marks & combining with 50 marks for SEE

ADDITIONAL MATHEMATICS – I	
Course Code: AM31	Credits: 0:0:0
Pre – requisites: Nil	Contact Hours: 45L
Course Coordinator: Mathematics Department	

Course Content

Unit I

Differential Calculus: Successive differentiation, nth derivatives of some standard functions, Leibnitz theorem, Polar curves. Angle between the radius vector and the tangent, angle between curves, length of the perpendicular from pole to the tangent, pedal equations. Taylor's and Maclaurin's expansions.

- Pedagogy / Course delivery tools:-Chalk and talk
- Links:-<https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: -<https://a.impartus.com/ilc/#/course/107625/1030>

Unit II

Integral Calculus: Introduction, Reduction formula, Reduction formula for $\int \sin^n x \, dx$, $\int \cos^n x \, dx$ and $\int \sin^n x \cos^m x \, dx$. Evaluation of double and triple integrals.

- Pedagogy / Course delivery tools:-Chalk and talk
- Links-<https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: -<https://a.impartus.com/ilc/#/course/107625/1030>

Unit III

Vector Algebra: Scalar and vectors. Vector addition and subtraction. Multiplication of vectors (Dot and Cross products). Scalar and vector triple product-simple problems. Vector functions of a single variable. Derivative of a vector function, geometrical interpretation. Velocity and acceleration.

- Pedagogy / Course delivery tools:-Chalk and talk
- Links:-<https://nptel.ac.in/courses/111/105/111105134>
- Impartus recording: -<https://a.impartus.com/ilc/#/course/107625/1030>

Unit IV

Vector Differentiation: Scalar and vector fields, gradient of a scalar field, directional derivative, divergence of a vector field, solenoidal vector, curl of a vector field,

irrotational vector. Laplace's operator. Vector identities connected with gradient, divergence and curl.

- Pedagogy / Course delivery tools:-Chalk and talk
- Links:-<https://nptel.ac.in/courses/111/105/111105134>
- Impartus recording: -<https://a.impartus.com/ilc/#/course/107625/1030>

Unit V

First Order Differential Equations: Solution of first order and first degree differential equations, variable separable methods, homogeneous equations, linear and Bernoulli's equations, exact differential equations.

- Pedagogy / Course delivery tools:-Chalk and talk, Power Point Presentation
- Links:-<https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: -<https://a.impartus.com/ilc/#/course/59742/295>

Text Books:

1. **B.S. Grewal** – Higher Engineering Mathematics, Khanna Publishers, 44th edition, 2017.
2. **Erwin Kreyszig** – Advanced Engineering Mathematics – Wiley Publication, 10th Edition, 2015.

Reference Books:

1. **H. K. Dass** – Higher Engineering Mathematics – S Chand Publications, 1998.
2. **B. V. Ramana** – Engineering Mathematics – Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2008.

Course Outcomes (COs):

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

1. Solve problems related to nth derivative to some standard functions, polar curves and power series expansions. (PO-1,,PO-2)
2. Apply the concept of reduction formula to determine the length, area, volume of revolution of an arc of the curve. (PO-1,,PO-2)
3. Solve the problems related to velocity and acceleration. (PO-1, PO-2)
4. Apply vector differentiation to identify solenoidal and irrotational vectors. (PO-1, PO-2)
5. Apply the concept of various methods to solve first order first degree differential equations. (PO-1, PO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	Marks	Course outcomes addressed
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		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5

Skill Lab 2:MATERIAL SYNTHESIS, CHARACTERIZATION AND AI-ASSISTED DATA INTERPRETATION	
Course Code: CHSL2	Credits: 0:0:1
Pre – requisites: 0	Contact Hours: 30P
Course Coordinator: Dr. AVSL Sai Bharadwaj	

Course Content

Introduction to the principles and methods of functional material synthesis, including precipitation, sol-gel, solution combustion, hydrothermal and other suitable techniques. Overview of relevant characterization techniques such as XRD, FTIR, thermal analysis and other available methods.

Introduction to interpretation of characterization data and use of AI tools for data analysis, including peak identification, comparison with reference data, pattern recognition and preliminary interpretation. Emphasis on critical evaluation of AI-assisted results using fundamental Chemical Engineering and materials science principles.

Students, in groups, will undertake a project involving synthesis of selected functional materials, characterization, AI-assisted analysis of experimental data and evaluation of suitable Chemical Engineering applications. Each group will execute the project and present the outcomes through a project presentation and report. This will be evaluated by the coordinator for 100 marks.

Text Books:

1. Cullity, B.D, 2nd Edition, Elements of X-Ray Diffraction. Addison-Wesley Series in Metallurgy and Materials.
2. J. M. Hollas – Modern Spectroscopy, 4th Edition, Wiley Publications, ISBN: 978-0-470-84416-8
3. M. E. Brown – *Introduction to Thermal Analysis: Techniques and Applications*, Edition 2, Kluwer Academic Publishers, eBook ISBN: 0-306-48404-8

Reference Books:

1. Sam Zhang, Lin Li & Ashok Kumar – Materials Characterization Techniques, CRC Press, 1st Edition

2. Robert M. Silverstein, Francis X. Webster & David J. Kiemle – *Spectrometric Identification of Organic Compounds*, 8th Edition, An Indian Adaption
3. Joseph I. Goldstein, Dale E. Newbury, Joseph R. Michael, Nicholas W.M. Ritchie, John Henry J. Scott, David C. Joy. – *Scanning Electron Microscopy and X-Ray Microanalysis*, Edition 4, eBook ISBN: 978-1-4939-6676-9

Course Outcomes (COs):

On successful completion of this course students will be able to

1. **Synthesize and characterize** functional materials using appropriate conventional and green synthesis techniques and analytical methods.(PO-1,2,3,6,7,8,9,10,11,PSO-1,3).
2. **Analyze and interpret** material characterization data using AI-assisted and digital tools to establish structure–property relationships and assess material performance.(PO-1,7,8,9,10,11,PSO-1,2)
3. **Evaluate and apply** synthesized materials for relevant Chemical Engineering applications in **energy, environmental protection, catalysis, water treatment, sensors and other emerging fields**, and communicate the findings through technical reports. .(PO-1,2,3,6,7,8,9,10,11,PSO-1,3)

IV SEMESTER

CHEMICAL REACTION ENGINEERING - I	
Course Code: CH41	Credits: 3:0:1
Pre – requisites: Chemical Process Calculations & Engineering Chemistry	Contact Hours: 45L+30P+45S
Course Coordinator: Dr. Rajeswari M Kulkarni	

Course Content

Unit I

Temperature dependency of rate constant

Interpretation of batch reactor data. Constant Volume batch reactor. Integral method of Analysis of data. Irreversible, zero, first, second and n^{th} order reactions (Unimolecular and bimolecular type), Overall orders from half-life method. Reversible first order reaction. Interpretation of batch reactor data by differential method of analysis.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- NPTEL: (1) Chemical Reaction Engineering 1 (Homogeneous Reactors), Prof K. Krishnaiah (2) Chemical Reaction Engineering - I, Prof. Bishnupada Mandal
- Impartus recording: <http://a.impartus.com/ilc/#/course/59750/295>
- Laboratory session: Effect of temperature on rate constant

Unit II

Design of ideal reactors: Concept of ideality. Development of design expressions for batch, tubular, and stirred tank reactors for both constant reactions and variable-volume reactions. Evaluation of rate equations from data obtained in these reactors. Comparison of ideal reactors. General graphical comparison.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- NPTEL: (1) Chemical Reaction Engineering 1 (Homogeneous Reactors), Prof K. Krishnaiah (2) Chemical Reaction Engineering - I, Prof. Bishnupada Mandal
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>
- Laboratory session: Reaction in Batch, tubular, and stirred tank reactors

Unit III

Multiple Reactor Systems. **Recycle reactors:** Introduction and qualitative treatment for single reactions only.

Design of reactors for multiple reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel and Series reactions (Only irreversible reactions must be considered).

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- NPTEL: (1) Chemical Reaction Engineering 1 (Homogeneous Reactors), Prof K. Krishnaiah (2) Chemical Reaction Engineering - I, Prof. Bishnupada Mandal
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>

Unit IV

Thermal characteristics of reactors: General graphical design procedure for non-isothermal reactors. Optimum temperature Progression.

Design of adiabatic reactors: Estimation of Conversion and Design of reactors solving material and energy balance equations simultaneously (For single/ simple reactions only).

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- NPTEL: (1) Chemical Reaction Engineering 1 (Homogeneous Reactors), Prof K. Krishnaiah (2) Chemical Reaction Engineering - I, Prof. Bishnupada Mandal
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>

Unit V

Basics of Non-Ideal flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. Dispersion model. Tanks in series model. Conversion in non-ideal flow reactors for simple systems.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- NPTEL: (1) Chemical Reaction Engineering 1 (Homogeneous Reactors), Prof K. Krishnaiah (2) Chemical Reaction Engineering - I, Prof. Bishnupada Mandal
- Impartus recording: <http://a.impartus.com/ilc/#/course/81470/295>
- Laboratory session: RTD studies in flow reactors

Text Books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.

2. Fogler, H. S., Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2001.

Reference Book:

1. Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1984.

Course Outcomes (COs):

On successful completion students will be able to

1. Interpret the types of reactions and the effect of temperature on the rate of reaction. Analyze the methods for determining kinetics of a reaction. (PO-1,2,5,7,8,9,11, PSO-1,3)
2. Develop expressions for batch, tubular and stirred tank reactors and evaluate rate equations. (PO-1,2,5,7,8,9, 11, PSO-1,3)
3. Compare the reactors and systems of multiple reactors. (PO-1, 2,5,7,8,9,11, PSO-1,3)
4. Elucidate thermal characteristics of reactors and their usage in design procedure. (PO-1,2,5,7,8,9,11, PSO-1,3)
5. Explicate the extent of non-ideality in a reactor. (PO-1,2,5,7,8,9,11, PSO-1, 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		
Lab experimental work & Record writing	15	CO1, CO2, CO3, CO4, CO5
Lab Test/viva/tutorial test	05	CO1, CO2, CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

PROCESS HEAT TRANSFER	
Course Code: CH42	Credits: 2:1:0
Pre – requisites: Engineering Mathematics	Contact Hours: 30L+ 30T+30S
Course Coordinator: Dr. Archana	

Course Content

Unit I

Introduction: Various modes of heat transfer and governing laws.

Conduction: Thermal conductivity, Steady state unidirectional heat flow through compound walls, Numerical problems. Heat conduction with heat generation in a slab, cylinder and sphere.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: <https://www.youtube.com/watch?v=xAcZ9-zNYIY>
- Impartus recording: <https://a.impartus.com/ilc/#/course/96145/452>

Unit II

Elementary treatment of unsteady state heat conduction: Biot number, Lumped heat capacity model, Numerical problems.

Insulation: Properties of insulation materials. Types of insulation, Critical and optimum thickness of insulation.

Extended Surfaces: Types of fins, fin efficiency. Fin effectiveness, Numerical Problems.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://www.youtube.com/watch?v=SUjhwuKtU14>
- Impartus recording: <https://a.impartus.com/ilc/#/course/96145/452>

Unit III

Convection: Individual and Overall heat transfer coefficients, LMTD, Dimensional Analysis, Empirical correlations for forced and natural convection.

Heat Transfer with Phase Change: Boiling phenomenon, nucleate boiling and film boiling, Condensation- Film and drop wise condensation. Nusselt equation.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Impartus recording: <https://a.impartus.com/ilc/#/course/96145/452>

Unit IV

Heat Transfer Equipment: Construction and working - Double pipe heat exchanger. Shell and tube heat exchangers. Condensers.

Design of Heat Transfer Equipment: Elementary design of double pipe heat exchanger and Shell and tube heat exchanger.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://www.youtube.com/watch?v=MdDbxktvecg>
- <https://www.youtube.com/watch?v=kns9UNZYMjI>
- Impartus recording: <https://a.impartus.com/ilc/#/course/96145/452>

Unit V

Evaporators: Types, Performance of tubular evaporator- evaporator capacity, evaporator economy, Multiple effect evaporators.

Radiation: Properties and definitions, Stefan-Boltzmann law, Wien's displacement law, Kirchhoff's law, View factors, Radiation between surfaces, Radiation involving gases and vapours. Radiation shields. Numerical Problems.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://www.youtube.com/watch?v=67PfCRGGY8c>
- Impartus recording: <https://a.impartus.com/ilc/#/course/96145/452>

Text Books:

1. McCabe, Unit Operations of Chemical Engineering, McGraw Hill, NY, 5th Edition, 2000.
2. Coulson, J.M and Richardson, J.F, Chemical Engineering, Vol 1, Chemical Engineering, Pergamon and ELBS, 5th Edition, McGraw Hill, 2000.

Reference Books:

1. Rao, Y.V.C., Heat Transfer, I Edition, University Press (India) Ltd, New Delhi, 2000.
2. Hollman, J. P., Heat Transfer, 8th Edition.
3. Kern, D. Q., Process Heat Transfer, McGraw Hill, NY, 1965.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Comprehend fundamental heat transfer laws and develop mathematical expressions for heat flux through multilayer systems. (PO-1,2,5, PSO-1)
2. Analyze critical thickness of insulation & its usage in insulating pipes. Develop relation for heat flow through fins & its relevance to industry. (PO-1,2, 3,4,5, PSO-1,3)
3. Comprehend correlations of convective heat transfer, LMTD, heat transfer coefficients, boiling and condensation phenomena. (PO-1,2,3, PSO-1)
4. Design various types of heat exchangers and condensers. (PO-1,3,4,5, PSO-1, 3)
5. Apprehend various types of evaporators and radiation heat transfer between surfaces. (PO-1,2, 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	CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Mini Project	10	CO1, CO2, CO4, CO5
Quiz/Presentations	10	CO3
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MASS TRANSFER-I	
Course Code: CH43	Credits: 2:1:0
Pre – requisites: - Engineering Chemistry	Contact Hours: 30L+ 30T+30S
Course Coordinator: Dr. V. Sravanthi	

Course Content

Unit I

Introduction: Various modes of mass transfer: Diffusion – Fick’s laws; Convection – mass transfer coefficient.

Diffusion in gases, liquids, and solids, Molecular picture. Measurement and estimation of diffusivities. Steady state unidirectional mass transfer through stagnant films of one and two immiscible fluids with equilibrium at interface. Numerical problems.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: nptel.ac.in/courses/103103145

Unit II

Convection: Mass transfer coefficients for laminar and turbulent flows and their correlations. Interpretation in terms of film model and movement of eddies. Overall mass transfer coefficients. Problems on mass transfer resistance.

Material balance for co-current, cross-current and counter-current operations. Concept of stages, efficiencies, cascades operation, continuous contacting equipment, NTU and HTU concepts.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: [https:// nptel.ac.in/courses/103103145](https://nptel.ac.in/courses/103103145)

Unit III

Humidification: General theory. Psychrometric chart. Concepts in humidification, dehumidification. Cooling towers.

Drying: Drying Equilibria. Drying rate curves. Mechanism of drying. Calculation of batch and continuous drying. Equipment for drying.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/103103154>

Unit IV

Crystallization: Factors governing nucleation and crystal growth rates. Controlled growth of crystals. Yield calculations and energy balance. Different types of crystallizer equipment. Fractional crystallization.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/103103154>

Unit V

Adsorption: Theories of adsorption. Isotherms, Industrial adsorbents. Stage wise operations, Adsorptions calculations and equipment.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/103103154>

Text Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Dutta, B.K., Principles of Mass Transfer and Separation Processes, 1st Edition, PHI, 2006.

Reference Books:

1. Narayanan, K.V., Lakshmikutty, B, Mass Transfer – Theory and Applications, 1st Edition, CBS, 2014.
2. Badger & Banchero, Introduction to Chemical Engineering, TMH, 6th Reprint, 1998.
3. Geankoplis, C. J., Transport Processes and Unit Operation, Prentice Hall (I), 2000.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Develop mathematical expression for one dimensional diffusion process and solve related problems. (PO-1, 2, 3,4,8,9 PSO-1)
2. Analyze stage wise operations and understands the concept of interphase mass transfer ((PO-1, 2, 3, 4,8,9 PSO-1)
3. Understand the concepts of humidification. Solve problems on the drying process and explain the types of dryers. (PO-1, 2, 3, 4,8,9 PSO-1)
4. Solve problems on crystallization and explain the types of crystallizers required for different crystallization process. (PO-1, 2,3, 4,8,9 PSO-1)
5. Comprehend the concepts of adsorption and ion exchange process. (PO-1, 2, 3, 4,8,9 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/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

CHEMICAL ENGINEERING THERMODYNAMICS	
Course Code: CH44	Credits: 2:1:0
Pre – requisites: Nil	Contact Hours: 30L+ 30T+30S
Course Coordinator: Dr. Brijesh	

Course Content

Unit I

Basic Concepts and First Law: System, surrounding, processes, state and properties- intensive and extensive properties, State and path functions, Reversible & irreversible processes, Zeroth law of thermodynamics. General statement of first law of thermodynamics, first law for cyclic process and non-flow processes, Derivation for closed system and steady state flow process- flow calorimeter and heat capacity.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/112105123/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/59749/295>

Unit II

P-V-T Behaviour: P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, Constant temperature, adiabatic and polytropic processes, Equations of state for real gases: Van der Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation, Principles of corresponding states, Generalized compressibility charts,

Second Law of Thermodynamics: General statements of the Second law, concept of Entropy, Carnot's principle, Calculations of entropy change, Third law of thermodynamics.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/112105123/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/59749/295>

Unit III

Thermodynamic Properties of Pure Fluids Fundamental property relations, Maxwell's equations, Equations for U and H, Effect of temperature on U, G, H and S, Entropy heat capacity relations, Relationship between Cp, Cv, Clapeyron equation, Gibbs-Helmholtz equation.

Properties of Solutions: Partial molar properties, Gibbs-Duhem equation, Chemical potential, Fugacity and fugacity coefficient, Henry's law, Activity coefficients, Property

changes of mixing, Activity & Activity coefficients. Ideal and non-ideal solutions.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/112105123>
- Impartus recording: <https://a.impartus.com/ilc/#/course/59749/295>

Unit IV

Phase Equilibria: criterion for VLE for ideal solutions, Raoult's law, P-x,y and T-x,y diagrams, Non-ideal solutions- Azeotropes types, VLE correlations – van Laar, Margules and Wilson equation. Consistency tests.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/112105123/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/59749/295>

Unit V

Chemical Reaction Equilibrium: Reaction stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, pressure on equilibrium constants and other factors affecting equilibrium conversion, Phase rule for reacting system.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: <https://nptel.ac.in/courses/112105123/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/59749/295>

Text Books:

1. Smith, J.M., Vanness, H.C., M.M. Abott., M.T. Swihart Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw Hill, 2019 October.
2. Narayanan, K.V., Textbook of Chemical Engineering Thermodynamics, Prentice Hall of India Private Limited, New Delhi, 2001.

Reference Book:

1. Rao, Y.V.C., Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.
2. B.G.Kyle, Chemical and process thermodynamics, 2nd edition, Prentice Hall of India Pvt. Ltd., 2000.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyse heat and work requirements for the given flow or non-flow processes. (PO-1,2, 3, PSO-1)
2. Determine Pressure, Volume and Temperature of fluids using equations of states. Evaluate Entropy and Thermodynamic efficiency of a process. (PO-1, 2, 3, PSO-1,2)
3. Evaluate thermodynamic properties of pure fluids and partial molar properties in solution. (PO-1, 2, 3, PSO-1,2)
4. Generate Vapour Liquid Equilibrium data for ideal and non-ideal solutions and check for their consistency. (PO-1,2, 3, PSO-1, 2)
5. Evaluate the feasibility and extent of conversion for any reaction. (PO-1, 2, 3, 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		
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

MATERIAL SCIENCE	
Subject Code: CHE451	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: <https://archive.nptel.ac.in/courses/113/102/113102080/>

Unit II

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

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

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

Unit III

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

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

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

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

Unit IV

Materials Processing: Metals and Alloys – Fabrications – Forming, Casting.

Thermal Processing: Annealing, Heat treatment of Steels. Surface hardening methods.

Ceramics – Fabrication and processing of glass

Polymers – Polymerization, Additives, Forming methods, Fabrication of elastomers and fibres.

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

Unit V

Corrosion and its Prevention: Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, Corrosion rate and its prediction, Prevention of corrosion. Corrosion charts.

Materials Selection and Design Considerations, Environmental considerations and recycling.

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

Text Books:

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

Reference Books:

1. Van Vlack, H.L., Elements of Materials Science, 2nd Edition, 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

ELECTROCHEMICAL TECHNOLOGY	
Subject Code: CHE452	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-kDQT10>
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 Wiley & 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

NON-CONVENTIONAL ENERGY SOURCES AND TECHNOLOGY	
Subject Code: CHE453	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=kS1OErXdvs>

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, 12, 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

PROBABILITY, STATISTICS & NUMERICAL METHODS	
Subject Code: CHE454	Credits: 3:0:0
Pre requisites: Basic Probability	Contact Hours: 45L+45S
Course Coordinator: Mathematics Faculty	

Course Content

Unit I

Statistics: Curve fitting by the method of least squares, fitting linear, quadratic and geometric curves, Correlation, Regression, Multiple Regression.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/619570/1030>

Unit II

Random Variables and Probability Distributions-I: Random variables (Discrete and Continuous), Probability density function, Cumulative density function, Mean, Variance, Binomial distribution, Poisson distribution.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/96127/452>
- <https://a.impartus.com/ilc/#/course/96151/1112>

Unit III

Probability Distributions-II: Uniform distribution, Exponential distribution, Gamma distribution, Normal distribution, Joint probability distribution (both discrete and continuous).

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/96127/452>
- <https://a.impartus.com/ilc/#/course/96151/1112>

Unit-IV

Sampling and Statistical Inference: Sampling distributions, Concepts of standard error and confidence interval, Central Limit Theorem, Type-1 and Type-2 errors, Level of significance, One tailed and two tailed tests, Z-test: for single mean, for single proportion, Student's t –test: for single mean, for difference between two means, F – test: for equality of two variances, Chi-square test: for goodness of fit, for independence of attributes.

- Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos
- Links: <https://nptel.ac.in/courses/111105035>
- Impartus Recording: <https://a.impartus.com/ilc/#/course/96151/1112>

Unit-V

Interpolation: Piecewise linear, quadratic and cubic interpolation, Cubic spline interpolation. Hermite interpolation.

Numerical Integration: Gauss Legendre one point, two point and three point techniques. Romberg integration.

Pedagogy / Course delivery tools: Chalk and talk, Power point Presentation, Videos

Links: <https://nptel.ac.in/courses/111106101>

Impartus Recording: <https://a.impartus.com/ilc/#/course/3111313/1447>

Text Books:

1. T. Veerarajan, Probability, Statistics and Random Processes – Tata McGraw Hill - 3rd edition-2009.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publisher, 6th edition, 2012.
3. B. S. Grewal, Higher Engineering Mathematics - Khanna Publishers - 44th edition-2017.

Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Publication – 10th edition-2015.
2. Kishor S. Trivedi, Probability & Statistics with Reliability, Queuing and Computer Science Applications, John Wiley & Sons, 2nd edition – 2008.

Course Outcomes (COs):

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

1. Fit a least squares curve to a given data and analyze the given discrete random data (PO-1, 2 & PSO-1, 2)
2. Apply the concept of discrete probability distributions to solve engineering problems. (PO-1,2 & PSO-1, 2)
3. Apply the concept of continuous probability distributions and calculate the marginal and conditional distributions of bivariate random variables to solve engineering problems. (PO-1,2 & PSO-1, 2)
4. Choose an appropriate test of significance and make inference about the population from a sample. (PO-1,2 & PSO-1,2)
5. Find functional values, derivatives, areas and volumes numerically from the given data. (PO-1, 2 & PSO-1, 2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	Marks	Course outcomes addressed
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		
Lab components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE) (Scaled to 50 Marks)	100	CO1, CO2, CO3, CO4, CO5

POLYMER PROCESSING TECHNOLOGY	
Subject Code: CHE455	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, 11, PSO-1)
2. Understand the main concepts of polymer extrusion. (PO-1, 2, 3, 11, PSO-1)
3. Test the manufactured polymer for suitability through injection moulding. (PO-1, 2, 3, 11, PSO-1)
4. Importance of compression moulding, characteristics of polymer for calendaring, Application of PVC products. (PO-1,11, PSO-1)
5. Study the importance of thermoforming and rotational moulding. (PO-1, 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
Assignment /Quiz	10	CO3, CO4, CO5
Semester End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

ABILITY ENHANCEMENT COURSE – IV INDUSTRIAL POLLUTION CONTROL AND SAFETY

Course Code: CHAEC46	Credits: 1:0:0
Pre – requisites: Engineering Chemistry, Environmental Studies	Contact Hours: 15L+15S
Course Coordinator: Dr. AVSL Sai Bharadwaj	

Course Content

Unit I

Introduction: Importance of environment for mankind. Types of pollution. Damages from environmental pollution. Global warming, Kyoto protocol.

Unit II

Wastewater treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Sludge treatment and disposal. Modern treatment methods. Physical and chemical characteristics. BOD, COD and their importance.

Link:

https://www.youtube.com/watch?v=sK0mlNUvPsM&list=PLbRMhDVUMngcKXmNPTPEbf-FNp_MVFSqD

Unit III

Air pollution aspects: Nature of air pollution. Classification of air pollutants. Sources of air pollutants. Plume behavior and dispersion of air pollutants. Effects of air pollution on human health, vegetation, and materials.

Link:

https://www.youtube.com/watch?v=5dukz1UOtKA&list=PLLy_2iUCG87BwOQUBS7WSdMVWHDXByk-w

Unit IV

Safety: Introduction to Process Safety- Intrinsic & Extrinsic Safety.

Introduction to Safety devices: Pressure relief valves. Ruptures discs. Blow down systems. Flare systems. Flame arrestors. Deflagration arrestors and explosion suppression. Personal safety devices.

Link: https://www.youtube.com/watch?v=Cs8DQ_9f5qM,
<https://www.youtube.com/watch?v=O97nymNUY-8>

Unit V

Process safety analysis: HAZAN and HAZOP comparison. Sequence of operability study. Risk analysis and estimation. Safety check list. ISO and OSHAS.

Link:

<https://www.youtube.com/watch?v=jFDWlKayrTc&list=PLbRMhDVUMngdXebaRB59KdKwstzuAovua>

Text Books:

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International, Reprint 2002.
2. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill, 1999.
3. Coulson & Richardson's Chemical Engineering Vol 6, Revised second edition by RK Sinnott.

Reference Books:

1. Perkins, H.C., Air Pollution, McGraw Hill, 1974.
2. Hagerty, D.J., Solid Waste Management, Van Nostrand Reinhold, 1973.
3. Metcalf and Eddy, Waste Water Engineering, Treatment, Disposal & Reuse, Tata McGraw Hill, 4th Edition, 2003.

Course Outcome (COs):

On successful completion of the course students will be able to

1. Comprehend the types of pollutions and their sources. (PO-1,6,11, PSO-1)
2. Understand waste water treatment technologies depending on the type of industrial waste waters. (PO-1,6,11, PSO-1)
3. Identify the sources of air pollution by carrying out air sample analysis and suggest schemes for its prevention. (PO-1,2,3,5,6,11, PSO-1)
4. Understand concept of safety and safety devices. (PO-1,2,3,5,6,11, PSO-1)
5. Apply techniques for process safety analysis. (PO-1,2,3,5,6,11, PSO-1,2)

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

POLLUTION CONTROL LABORATORY	
Course Code: CHL47	Credits: 0:0:1
Pre – requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. AVSL Sai Bharadwaj	

Course Content

List of experiments:

1. Determination of pH and conductivity of samples
2. Determination of alkalinity of samples.
3. Determination of acidity of samples.
4. Determination of turbidity of sample using Nephelo turbidometer.
5. Determination of dissolved, suspended and volatile solids.
6. Determination of optimum coagulant dosage using Jar test.
7. Settleable and suspended particulate matter in air using high volume sampler.
8. Determination of chloride, iodide, nitrate ions in water samples using Ion selective electrode.
9. Determination of Biological Oxygen Demand.
10. Determination of Chemical Oxygen Demand.
11. Dissolved oxygen determination using DO meter.
12. Determination of viscosity of given sample using Brookfield Viscometer.
13. Determination concentration of Sodium, Potassium, Calcium using flame photometer.
14. Determination of concentration of CO_x, SO_x, NO_x in air sample.
15. Estimation of Chromium using UV Visible Spectrophotometer.

Course Outcome (COs):

On successful completion of the laboratory course, the student will be able to

1. Characterize water in terms of the pollutants present in it and determine its quality. (PO-2, 3, 4, 5, 6, 7, 8, 11, PSO-1,3)
2. Determine pollutants in air. (PO-2, 3, 4, 5, 6, 7, 8, 9, 10,11, PSO-1,3)
3. Use of instruments to determine pollutant compositions. (PO-2, 3, 4, 5, 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
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 HEAT TRANSFER LAB	
Course Code: CHL48	Credits: 0:0:1
Pre – requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. Rama Sivakiran Reddy	

Course Content

1. To determine the heat transfer coefficient for natural convection from bare and finned tubes.
2. To evaluate the heat transfer coefficient in a vertical shell-and-tube condenser.
3. To investigate the heat transfer coefficient in a horizontal shell-and-tube condenser.
4. To analyze the heat transfer coefficient in a helical coil heat exchanger.
5. To determine the emissivity of a given surface.
6. To study the effect of geometry on the heat transfer coefficient during natural convection.
7. To determine the heat transfer coefficient in a packed-bed system.
8. To evaluate the overall heat transfer coefficient in a double-pipe heat exchanger.
9. To determine the heat transfer coefficient in a jacketed vessel.
10. To determine the optimum insulation thickness for minimizing heat loss.
11. To investigate the transient heat conduction characteristics of a solid.
12. To determine the heat transfer coefficient in a fluidized-bed system.
13. To determine the heat transfer coefficient and evaporation rate in an evaporator.
14. To determine the efficiency and heat transfer characteristics of a solar water heater.
15. To determine the overall heat transfer coefficient in a spiral plate heat exchanger.
16. To determine the overall heat transfer coefficient in a cross-flow heat exchanger.

Links: <https://vlab.amrita.edu/?sub=1&brch=194>

Course Outcome (COs):

On completion of the laboratory, the student will be able to

1. Determine the design parameters for design and selection of heat exchangers. (PO-1,2, 3, 8, 9, 10, PSO-1,3)
2. Evaluate the performance of different types of heat exchangers. (PO-1,2,3,8,9, 10, PSO-1,3)
3. Explain the necessity of insulation and fins. (PO-1,2,3,9,10 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

PROCESS EQUIPMENT DRAWING	
Course Code: CHL49	Credits: 0:0:1
Pre – requisites: -	Contact Hours: 30P
Course Coordinator: Dr. J. Koteswararao	

Course Content

List of drawings to be prepared using AutoCAD

1. Types of Joints – Flange, Union, Cotter
2. Vessel Components - Types of Heads, Types of Nozzles, Types of Supports, Agitators, Stuffing Box
3. Valves – Ball, Stop, Globe, Gate
4. Equipment - Reaction Vessel, Distillation Column, Evaporator, Shell and Tube Heat Exchanger
5. Piping and Instrumentation Diagrams
 - Pedagogy/Course delivery tools: Chalk and talk/ppt
 - Links: **AutoCAD Basic Tutorial for Beginners**
<https://www.youtube.com/watch?v=cmR9cfWJRuu>

Pressure Vessel Tank

<https://www.youtube.com/watch?v=X3wY6e4QLaQ>

Saddle Support Side View in AutoCAD

<https://www.youtube.com/watch?v=gttk3MpjR0k>

Course Outcome (COs):

On successful completion of the course students will be able to

1. Prepare Engineering Drawing using AutoCAD. (PO-1, 2,5,6,8,9,11, PSO-1, 2,3)
2. Show details of Process Equipment through Drawings. (PO-1,2,5,6,8 9,11, PSO-1,2,3)
3. Draw PI & PID for chemical operations. (PO-1,2,5,7, 8,9,11, PSO-1,2,3)

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

ADDITIONAL MATHEMATICS – II	
Course Code: AM41	Credits: 0:0:0
Pre – requisites: Nil	Contact Hours: 42L
Course Coordinator : Mathematics Department	

Course Content

Unit I

Differential Calculus- I: Partial differentiation, Euler’s theorem, total differential coefficient, differentiation of composite and implicit functions.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/107625/1030>

Unit II

Differential Calculus- II: Jacobian and Properties. Taylor’s theorem for function of two variables, maxima and minima for functions of two variables.

- Pedagogy / Course delivery tools: Chalk and talk
- Links <https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/107625/1030>
- <https://a.impartus.com/ilc/#/course/59742/295>

Unit III

Vector Integration: Line integrals, surface integrals and volume integrals. Green’s theorem, Stokes’ and Gauss divergence theorem (without proof) and problems, orthogonal curvilinear coordinates.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://nptel.ac.in/courses/111/105/111105134/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/107625/1030>

Unit IV

Higher Order Differential Equations: Higher order linear differential equations, method of variation of parameters, Cauchy’s and Legendre’s homogeneous differential equations.

Pedagogy / Course delivery tools: Chalk and talk

- Links: <https://nptel.ac.in/courses/111/105/111105121/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/96127/452>
- <https://a.impartus.com/ilc/#/course/59742/295>

Unit V

Probability: Introduction. Sample space and events. Axioms of probability. Addition and multiplication theorems. Conditional probability- illustrative examples. Bayes theorem – examples.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: <https://nptel.ac.in/courses/111/107/111107119/>
- Impartus recording: <https://a.impartus.com/ilc/#/course/283623/703>

Text Books:

1. **B.S. Grewal**, Higher Engineering Mathematics, Khanna Publishers, 44th edition, 2017.
2. **Erwin Kreyszig**, Advanced Engineering Mathematics, Wiley Publication, 10th Edition, 2015.

Reference Books:

1. **H. K. Dass**, Higher Engineering Mathematics, S Chand Publications, 1998
2. **B. V. Ramana**, Engineering Mathematics, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2008.

Course Outcomes (COs):

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

1. To carryout differentiation of function of several variables. (PO-1, PO-2)
2. Solve the problems related to Jacobians, the extreme values of a function and Taylors series. (PO-1, PO-2)
3. Exhibit the interdependence of line, surface and volume integrals using integral theorems. (PO-1, PO-2)
4. Find the solution of second and higher order ODEs with constant and variable coefficients. (PO-1, PO-2)
5. Solve the problems on conditional probability and Baye's theorem. (PO-1, PO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	Marks	Course outcomes addressed
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		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5

Skill lab 3: ENVIRONMENTAL LIFE CYCLE ASSESSMENT LAB	
Course Code: CHSL3	Credits: 0:0:1
Pre – requisites: Nil	Contact Hours: 30P
Course Coordinator: Dr. Rama Sivakiran Reddy	

Course Content

Cradle-to-Gate LCA of a Chemical Product: Construction of cradle-to-gate product systems, selection of appropriate background datasets and Life Cycle Impact Assessment (LCIA). Identification and interpretation of major environmental hotspots in the chemical product life cycle. Comparison of environmental impacts across relevant midpoint impact categories. Evaluation of environmental trade-offs, burden shifting and identification of environmentally preferable production pathways. Development of alternative scenarios involving reduction in energy consumption, changes in electricity mix, fuel substitution and process-energy efficiency. Comparison and interpretation of environmental benefits associated with energy and utility optimization.

Evaluation is based on case studies presented by group of students **100 Marks**

Case Study: Selection of a chemical product or chemical manufacturing process for detailed Life Cycle Assessment. Review of published LCA studies and relevant scientific literature to identify functional units, system boundaries, inventory data, impact-assessment methods and major environmental concerns. Development of an LCA model using **openLCA** and **ecoinvent**, analysis and interpretation of environmental impacts, identification of hotspots and evaluation of potential improvement strategies. Comparison of obtained results with published literature. Preparation and submission of a technical report documenting the goal and scope, methodology, assumptions, inventory, results, interpretation, limitations and conclusions of the case study.

Text Books:

1. Olivier Jolliet, Myriam Saade-Sbeih, Shanna Shaked, Alexandre Jolliet, Pierre Crettaz (2016) Environmental Life Cycle Assessment 1st Edition, CRC Press, USA

Reference Books:

1. Guinée, J. B. (Ed.). (2002). Handbook on life cycle assessment: operational guide to the ISO standards (Vol. 7). Springer Science & Business Media.

Web links and Video Lectures (e-Resources):

1. NPTEL Course: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
2. LCA Open Source Software (Open LCA): <https://www.openlca.org>
3. LCA Free Databases: <https://nexus.openlca.org>

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Develop cradle-to-gate and comparative Life Cycle Assessment models (PO-1, 7, 11 PSO-1)
2. Analyze the environmental impacts of chemical processes. (PO-1,7,11, PSO-1)
3. Conduct a case study on the life cycle assessment of a chemical product and prepare technical report. (PO-1,2,3, 5,7,1, PSO-1)