RAMAIAH
Institute of Technology

CURRICULUM

Outcome Based Education
(Academic Year 2023 – 2024)

CHEMICAL ENGINEERING

III & IV SEMESTER B.E.

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

About the Institute

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

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

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

About the Department

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

VISION OF THE INSTITUTE

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

MISSION OF THE INSTITUTE

MSRIT shall meet the global socio-economic needs through

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

QUALITY POLICY

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

VISION OF THE DEPARTMENT

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

MISSION OF THE DEPARTMENT

- 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.
- To offer a programme that inculcates creative thinking and lifelong learning contributing to the advancements in chemical sciences and its application.
- To foster principles of sustainability and promote environmentally benign technologies for the benefit of society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

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

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

PROGRAM OUTCOMES (POs):

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

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

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

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

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

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

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

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

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

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

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

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

PROGRAM SPECIFIC OUTCOMES (PSOs):

The Chemical Engineering graduate will be able to

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

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

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

Semester wise Credit Breakdown for B.E Degree Curriculum
Batch 2022-26

Semester / Course Category	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Basic Sciences (BSC)	08	08	03	03	--	--	--	--	22
Engineering Sciences (ESC)	08	09	--	--	--	--	--	--	17
Humanities, Social Sciences and Management (HSMC)	02	02	--	--	03	03	--	--	10
Ability Enhancement Course (AEC)	02	01	01	01	01	--	03	--	09
Universal Human Values (UHV)	--	--	02	--	--	--	--	--	02
Professional Core Courses (PCC)	--	--	11	12	12	06	04	--	45
Integrated Professional Core Course (IPCC)	--	--	04	04	03		04	--	15
Professional Elective Courses (PEC)	--	--	--	--	03	06	03	--	12
Institutional Open Elective Courses (IOE)	--	--	--	--	--	03	03	--	06
Internship (INT)	--	--	--	Yes	--	--	--	05	05
Mini Project / Project Work (PW)	--	--	--	--	--	04	03	10	17
Non Credit Mandatory Courses (NCMC)	--	--	Yes	--	Yes	--	--	Yes	--
Total Credits	20	20	21	20	22	22	20	15	160

SCHEME OF TEACHING III SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours/week
				L	T	P	Total	
1.	CH31	Integral Transforms and Complex Analysis	BSC	2	1	0	3	4
2.	CH32	Momentum Transfer	IPCC	3	0	1	4	5
3.	CH33	Chemical Process Calculations	PCC	2	1	0	3	4
4.	CH34	Mechanical Operation	PCC	3	0	0	3	3
5.	CH35	Technical Chemistry	PCC	3	0	0	3	3
6.	CHL36	Technical Chemistry Lab	PCC	0	0	1	1	2
7.	CHL37	Unit Operation Lab	PCC	0	0	1	1	2
8.	UHV38	Universal Human Values	UHV	2	0	0	2	2
9.	CHAEC39	Ability Enhancement Course-III	AEC	1	0	0	1	1
			Total	**16**	**2**	**3**	**21**	**26**
10	PE83	Physical Education		NCMC			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 VIII semesters. Qualifying is mandatory for the award of the degree.	
	YO83	Yoga						
	NS83	NSS						
12	AM31	Additional Mathematics - I *	Mathematics	NCMC			**0 0 0 0 3**	

Nomenclature: BSC: Basic Science Course**, IPCC:** Integrated Professional Core Course**, PCC:** Professional Core Course**, HSMC:** Humanity and Social Science & Management Courses**, AEC–**Ability Enhancement Courses**, UHV:** Universal Human Value Course, **NCMC**: Non-credit Mandatory Course

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

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with practical of the same course. Credit for IPCC is 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 1). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated only by CIE (no SEE). However, questions from the practical part of IPCC can be included in the SEE question paper.

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 VIII semesters and shall attend the course from the III semesters and upto end of VIII semesters to complete all the formalities of the course and appear for the SEE. Marks scored in SEE shall be included in the VIII 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. SEE marks will be allotted by the concerned course teacher based on attendance and performance in the practice sessions/field in the ratio of 50:50. Maximum CIE marks are 50. SEE should be awarded by the course teacher every semester (III to VIII) for 50 marks and marks scored by the student are scaled down to 50 in the VIII semester.
4. The students who take a course on Physical Education and Yoga, he/she has to take up the semester end practical examination prescribed for 100 marks. The students who opt for NSS course have to submit report and attend viva-voce examination. The marks of the report shall be 50 marks and for the presentation/viva-voce 50 marks. SEE scale down to 50 marks.
5. 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, Inter/Intra Institutional Internship: All the students admitted under the lateral entry category shall have to undergo a mandatory summer Internship of 02 weeks which is an NCMC course, during the intervening vacation of the III and IV semesters. Summer Internship shall include Inter / Intra Institutional activities. A Viva-voce examination shall be conducted during the IV semester. The internship shall be considered as a head of passing and shall be considered for vertical progression and for the award of the degree. Those, who do not take up / complete the internship shall be declared fail and shall have to complete during subsequent examination after satisfying the internship requirements during subsequent semesters.

*** 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. 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. Incase 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.

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

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

SCHEME OF TEACHING IV SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours/Week
				L	T	P	Total	
1.	CH41	Probability Models and Design of Experiments	BSC	2	1	0	3	04
2.	CH42	Chemical Reaction Engineering-I	IPCC	3	0	1	4	05
3.	CH43	Process Heat Transfer	PCC	2	1	0	3	04
4.	CH44	Mass Transfer-I	PCC	2	1	0	3	04
5.	CH45	Chemical Engineering Thermodynamics	PCC	2	1	0	3	04
6.	CHL46	Pollution Control Lab	PCC	0	0	1	1	02
7.	CHL47	Heat Transfer Lab	PCC	0	0	1	1	02
8.	CHL48	Process Equipment Drawing (AutoCAD)	PCC	0	0	1	1	02
9.	CHAEC49	Ability Enhancement Course-IV	AEC	1	0	0	1	01
10.	INT410	Inter/ Intra Institutional Internship	NCMC	0	0	0	0	-
11.	AM41	Additional Mathematics – II *	NCMC	0	0	0	0	-
		Total		**12**	**4**	**4**	**20**	**28**

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

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

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with practical of the same course. Credit for IPCC is 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 1). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated only by CIE (no SEE). However, questions from the practical part of IPCC can be included in the SEE question paper.

*** 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. In case, any student fails to secure the minimum 40% of the prescribed CIE marks, he/she shall be deemed to have secured an F grade. In such a case, the student has to fulfill the requirements during subsequent semester/s to appear for CIE. Incase 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.

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

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

III SEMESTER

INTEGRAL TRANSFORMS AND COMPLEX ANALYSIS	
Course Code: CH31	**Credits: 2:1:0**
Pre – requisites: Calculus	**Contact Hours: 28L+14T**
Course Coordinator: Mathematics Department	

Course Content

Unit I

Laplace Transforms: Definition, transforms of elementary functions, properties of Laplace transforms, existence conditions, transform of derivatives, integrals, multiplication by t^n, division by t, evaluation of integrals by Laplace transforms. Transform of Periodic function.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/111/105/111105134
- Impartus recording: https://a.impartus.com/ilc/#/course/59742/295

Unit II

Application of Laplace Transforms: 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
- Links: https://nptel.ac.in/courses/111/105/111105134
- Impartus recording: https://a.impartus.com/ilc/#/course/59742/295

Unit III

Complex Differentiation: 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
- Links: https://nptel.ac.in/courses/111103070
- https://nptel.ac.in/courses/111/105/111105035/
- Impartus recording: https://a.impartus.com/ilc/#/course/96127/452

Unit IV

Complex Integration: 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, PowerPoint presentation, Videos
- Links: https://nptel.ac.in/courses/111103070
- Impartus recording: https://a.impartus.com/ilc/#/course/96127/452

Unit V

Fourier Series: Periodic functions, Dirichlet conditions, Fourier series of periodic functions of period 2π and arbitrary period, complex form of Fourier series, half range Fourier series, Practical harmonic analysis

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptelvideos.com/video.php?id=141
- https://nptelvideos.com/video.php?id=142&c=1
- Impartus recording: https://a.impartus.com/ilc/#/course/107622/533

Text Books:

1. Erwin Kreyszig –Advanced Engineering Mathematics – Wiley publication – 10th edition-2015.
2. B. S. Grewal –Higher Engineering Mathematics – Khanna Publishers – 44th edition – 2017.

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. Determine Laplace transform of standard functions. (PO-1, PO-2, PSO-2)
2. Solve initial and boundary value problems using Laplace transforms. (PO-1, PO-2, PSO-2)
3. Examine and construct analytic functions. (PO-1, PO-2 & PSO-2)
4. Classify singularities of complex functions and evaluate complex integrals. (PO-1, PO-2, PSO-2)
5. Construct the Fourier series expansion of functions/tabulated data. (PO-1, PO-2, PSO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, 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
Quiz/Presentations	10	CO3, CO4, CO5
Semester-End Examination (SEE)	100 (Scale down to 50 Marks)	CO1, CO2, CO3, CO4, CO5

MOMENTUM TRANSFER	
Course Code: CH32	**Credits: 3:0:1**
Pre – requisites: Nil	**Contact Hours: 42L+14P**
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-Poisuelle 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=3fpCyjUn-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=QGVLPTWq2qQ
- 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. Evaluate different types of fluids and measure fluid pressure. (PO-1, PO-2, PSO-1)
2. Analyse the relationship between kinetic and potential energy and pressure energy in complex flow systems using Bernoulli's equation. (PO-1, PO-2, | PO-4, PSO-1, PSO-3)
3. Comprehend various types of pumps and transportation and metering devices for fluid handling. (PO-1, PO-2, PSO-1)
4. Analyse and calculate friction factor for different types of flow channels. (PO-1, PO-2, PO-4, PSO-1, PSO-3)
5. Comprehend flow of compressible fluids under adiabatic and isothermal flow conditions. Apply dimensional analysis for establishing correlations for process variables. (PO-1, PO-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, 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: Nil	**Contact Hours: 28L+14T**
Course Coordinator: Dr. J Koteswara Rao	

Course Content

Unit I

Basic Chemical Calculations: Fundamentals and derived units, Conversion of units. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. Concept of mole, mole fraction etc. Compositions of mixtures of solids and liquids and gases. Use of semi log and log-log graphs, Triangular graphs.

- 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=7X3LNoSydQc&list=PL23LJMmRTn8fwtijrPEgIbqZAaKCc3oEg&index=5 https://www.youtube.com/watch?v=bYW70-nsfGc&list=PL23LJMmRTn8fwtijrPEgIbqZAaKCc3oEg&index=6

Unit II

Vapor-Gas Concepts: Ideal gas law calculations, Vapor pressure concepts and calculations for miscible and immiscible systems. Humidity related terms, humidity chart, and humidification and dehumidification operation.

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

Unit III

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=LtSA06dy5MY

Unit IV

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: http://www.nitttrc.edu.in/nptel/courses/video/103103165/L09.html

Unit V

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: General Steady State Energy Balance equation. Heat of Formation, Heat of Reaction, Heat of Combustion, Heat of Solution. 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.digimat.in/nptel/courses/video/103103165/L19.html

Text Books:

1. Hougen, O.A., Waston, 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.

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. Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd Edition, 2005.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply various types of unit systems and convert units from one system to another. (PO-1, PO-2, PO-3, PO-12, PSO-1)

2. Develop strategy for solving problems involving gases, vapours etc. (PO-1, PO-2, PO-3, PO-12, PSO-1)
3. Adopt the tools learned from the course to solve numerical problems which contain one or more unit operations. (PO-1, PO-2, PO-3, PO-12, PSO-1)
4. Able to solve material balance problems involving reactions. (PO-1, PO-2, PO-3, PO-12, PSO-1)
5. Develop mathematical relations for both mass and energy balances for different processes. (PO-1, PO-3, PO-12, 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

MECHANICAL OPERATION	
Course Code: CH34	**Credits: 3:0:0**
Pre – requisites: Engineering Mathematics	**Contact Hours: 42L**
Course Coordinator: Dr. Sai Bharadwaj	

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
- Links: https://nptel.ac.in/courses/103107123
- Impartus recording: http://a.impartus.com/ilc/#/course/81470/295

Unit II

Size Reduction: Introduction – types of forces used for communition, criteria for communition, characteristics of communited 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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. Classify and suggest different type of separation processes required for a given feed material. (PO-1, PO-2, PO-3, PO-12, PSO-1, PSO-3)
2. Select suitable equipment for size reduction depending on the type and size of the material. (PO-1, PO-2, PO-3, PO-12, PSO-1, PSO-3)
3. Analyse the terminal velocity of the particles and understand fluid flow through packed and fluidized bed. (PO-1, PO-2, PO-3, PO-12, PSO-1, PSO-3)
4. Apprehend filtration problems and design thickener. (PO-1, PO-2, PO-3, PO-12, PSO-1, PSO-3)
5. Comprehend mixing processes, conveying of solids and calculate the power requirements. (PO-1, PO-2, PO-3, PO-12, 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

TECHNICAL CHEMISTRY	
Course Code: CH35	**Credits: 3:0:0**
Pre – requisites: CY12/22	**Contact Hours: 42L**
Course Coordinator: Dr. Nagaraju Kottam & Dr. S B 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–branching Chain reactions. 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: Unit 4.pmd (ncert.nic.in)

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 molecular weight. Osmotic pressure- determination of molecular weight and experimental measurements. Elevation of boiling point. Determination of molecular weight by ebullioscopy method. Depression of freezing point, determination of molecular weight. Isotonic solutions and abnormal molecular weights. Pedagogy / Course delivery tools: Chalk and talk/ppt

- Links: Unit_2.pmd (ncert.nic.in)

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: Unit_10.pmd (ncert.nic.in)

Unit IV

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

- Pedagogy / Course delivery tools: Chalk and talk/ppt
- Links: Saf (iitpk.com)

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: Unit_16.pmd (ncert.nic.in)

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.

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. Bahl, A. and Bahl B.S., A Text Book of Organic Chemistry, 15th Edition.S. Chand and & Co, New Delhi, 1998.
6. 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 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, PO-2, PO-7, PSO-1)
2. Explain catalytic reactions and the manufacture of dyes and applications in industry. (PO-1, PO-2, PO-3, PO-7, PSO-1)
3. Write reaction mechanisms in various types of reactions. (PO-1, PO-2, PO-3, PO-7, PSO-1)
4. Identify the different organic reactions using the various industries in the manufacture of drugs and organic compounds. (PO-1, PO-2, PO-3, PO-7, PSO-1)
5. Explain manufacture of soap and detergents, and their cleaning action mechanism. (PO-1, PO-2, PO-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

TECHNICAL CHEMISTRY LAB	
Course Code: CHL36	**Credits: 0:0:1**
Pre – requisites: CYL17/27	**Contact Hours: 14P**
Course Coordinator: Chemistry Faculty	

Course Content

1. Determination of partition coefficient of iodine between water and carbon tetrachloride.
2. Study of Kinetics of the reaction between K2S2O8 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. Flame photometric determination of potassium / calcium in the given test solution.
11. Preparation of acetanilide by acetylation of aniline using acetic anhydride.
12. Determination of acid value, iodine value and saponification value of the given sample of oil.
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, PO-2, PSO-1, PSO-3)
2. Preparation of organic compounds, TLC and analysis of oils and fats (PO-1, PO-2, PSO-1, PSO-3)
3. Effect of salt on CST and kinetics of the reaction (PO-1, PO-2, PO-3, PO-12, PSO-1, PSO-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

UNIT OPERATION LAB	
Course Code: CHL37	**Credits: 0:0:1**
Pre – requisites: Nil	**Contact Hours: 14P**
Course Coordinator: Sri Sagar J S	

Course Content

1. Air permeability
2. Ball mill
3. Batch sedimentation
4. Drop weight crusher
5. ICI sedimentation
6. Jaw crusher
7. Leaf filter
8. Plate and frame filter press
9. Screen effectiveness
10. Sieve analysis
11. Flow rate measurement using Orifice meters
12. Flow over Notches
13. Hydraulic coefficients – Open Orifice
14. Friction in Annulus
15. Friction in Helical Coils

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Perform particle size analysis and evaluate performance of size reduction and filtration equipment (PO-1, PO-3, PSO-1, PSO-3)
2. Measure flow rate of incompressible fluids. Determine energy loss due to friction in flow systems (PO-1, PO-2, PO-3, PO-4, PSO-1, PSO-3)
3. Suggest their applications (PO-1, PO-3, PSO-1, PSO-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

UNIVERSAL HUMAN VALUES	
Course Code: UHV38	**Credits: 2:0:0**
Pre – requisites: Nil	**Contact Hours: 28L**
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/F2KVW4WNnS8

- Links: Harmony in family- Respecthttps://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. **B L Bajpai**, 2004, *Indian Ethos and Modern Management*, New Royal Book Co., Lucknow. Reprinted 2008.
2. **PL Dhar, RR Gaur**, 1990, *Science and Humanism*, Commonwealth Publishers.
3. **Sussan George**, 1976, *How the Other Half Dies*, Penguin Press. Reprinted 1986, 1991
4. **Ivan Illich**, 1974, *Energy & Equity*, The Trinity Press, Worcester, and HarperCollins, USA
5. **Donella H. Meadows, Dennis L. Meadows, Jorgen Randers**, William W. Behrens III, 1972, limits to Growth, Club of Rome's Report, Universe Books.
6. **Subhas Palekar**, 2000, *How to practice Natural Farming*, Pracheen(Vaidik) Krishi Tantra Shodh, Amravati.
7. **A Nagraj**, 1998, *Jeevan Vidya ek Parichay*, Divya Path Sansthan, Amarkantak.
8. **E.F. Schumacher**, 1973, *Small is Beautiful: a study of economics as if people mattered*, Blond & Briggs, Britain.
9. **A.N. Tripathy**, 2003, *Human Values*, New Age International Publishers.

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=PLWDeKF97v9SP7wSlapZcQRrT7OH0ZlGC4
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, PO-8)

Course Assessment and Evaluation :

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 • Any other	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: CHAEC39	**Credits: 1:0:0**
Pre – requisites: Nil	**Contact Hours: 14L**
Course Coordinator: Dr. Sai Bharadwaj	

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 Powerpoint presentation
- Links for topic: https://onlinecourses.nptel.ac.in/noc21_ce47/preview
- https://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 Powerpoint 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 Powerpoint presentation.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint 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 Powerpoint 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 (OpenLCA), Case Studies and Examples Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint 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 (OpenLCA):** https://www.openlca.org
2. **LCA Free Databases:** https://nexus.openlca.org

Course Outcomes (COs):

On successful completion of this course students will be able to

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

Mapping Course Outcomes with Program Outcomes:

	PO												PSO		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1		1					3					3	1		
2		1					3					3	1		
3		1					3					3	1		
4		1					3					3	1		
5		1					3					3	1		

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO 1, 2 & 3
Internal Test-II	30	CO 3, 4 & 5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment	10	CO 1, 2, 3, 4 & 5
Case Study	10	CO 1, 2, 3, 4 & 5
Semester End Examination (SEE)	50	CO 1, 2, 3, 4 & 5

PHYSICAL EDUCATION	
Course Code: PE83	**Credits: NCMC**
Pre – requisites: Nil	
Course Coordinator: Dr. Kiran Kumar H K	

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 8th Semester.
6. The final marks shall be calculated after scaling down CIE to 50 marks & combining with 50 marks for SEE.

YOGA	
Course Code: YO83	**Credits: NCMC**
Pre – requisites: Nil	
Course Coordinator: Dr. Hari Chandra B P & Dr. Parimala P	

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.

Course Content

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, Paschimotasana, Purvothanasana, Bharadwajasana, Amruthasana, Parivruttha Trikonasana, Parsvakonasana, Ustrasana, Padmasana, Jaaanushirshasana, Navasana, Ardhachakrasana, Ardhakatichakrasana, 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, shoonyavaayu 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 8th 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: NS83	**Credits: NCMC**
Pre – requisites: Nil	
Course Coordinator: Dr. Puttabore Gowda & Dr. Siddaraju C	

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: 28L**
Course Coordinator: Dr. Shashi Prabha Gogate S	

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/ https://nptel.ac.in/courses/111/104/111104144/
- Impartus recording: https://a.impartus.com/ilc/#/course/107625/1030

Unit II

Integral Calculus: Introduction, Reduction formula, Reduction formula for , and . Evaluation of double and triple integrals.

- Pedagogy/Course delivery tools: Chalk and Talk
- Links: https://nptel.ac.in/courses/111/105/111105121/
- 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 avector 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.
2. Apply the concept of reduction formula to determine the length, area, volume of revolution of an arc of the curve.
3. Solve the problems related to velocity and acceleration.
4. Apply vector differentiation to identify solenoidal and irrotational vectors.
5. Apply the concept of various methods to solve first order first degree differential equations.

IV SEMESTER

PROBABILITY MODELS AND DESIGN OF EXPERIMENTS	
Course Code: CH41	**Credits: 2:1:0**
Pre – requisites: Calculus	**Contact Hours: 28L+14P**
Course Coordinator: Mathematics department	

Course Content

Unit I

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

Probability Distributions: Introduction to Random Variables, Binomial distribution, Poisson distribution.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/102101056
  https://nptel.ac.in/courses/111/107/111107119/
- Impartus recording: https://a.impartus.com/ilc/#/course/96127/452

Unit II

Probability Distributions: Uniform distribution, Exponential distribution, Gamma distribution and Normal distribution.

Joint probability distribution: Joint probability distribution (both discrete and continuous), Conditional probability, Conditional expectation.

- Pedagogy / Course delivery tools: Chalk and talk
- Links:https://nptel.ac.in/courses/102101056
- Impartus recording: https://a.impartus.com/ilc/#/course/96127/452

Unit III

Sampling and Statistical Inference: Sampling distributions, central limit theorem, concepts of standard error and confidence interval, level of significance, type I and type II errors, one tailed and two tailed tests, Z-test: for single mean, for single proportion and for difference between means, Student's t –test: for single mean and for difference between two means, F – test for equality of two variances, Chi-square test: for goodness of fit and for independence of attributes.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/102101056
  https://nptel.ac.in/courses/111/107/111107119/
- Impartus recording: https://a.impartus.com/ilc/#/course/96151/1112

Unit IV

ANOVA and Experimental design: Analysis of variance (ANOVA), assumptions, One way and two-way classification. Basics of experimental design, Randomized Complete Block Design (RCBD), Randomized Block Design (RBD) Advantages/disadvantages of each design.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/102101056
- Impartus recording: https://a.impartus.com/ilc/#/course/96151/1112

Unit V

Experimental design: Latin Square Design, Construction and arrangement, Analysis, Relative efficiency of LSD over RBD and RCBD. Graeco Latin Square Design: Construction and arrangement, data analysis. Factorial Experiments: 22 and 23 Designs, the general 2k Design.

- Pedagogy / Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/102101056
- Impartus recording: https://a.impartus.com/ilc/#/course/96151/1112

Text Books:

1. B. S. Grewal - Higher Engineering Mathematics - Khanna Publishers - 44th edition-2017.
2. T. Veerarajan - Probability, Statistics and Random Processes – Tata McGraw Hill - 3rd edition-2009.
3. Douglas C. Montgomery – Design and Analysis of Experiments – Wiley publication – 10th edition- 2019.

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, analyze the given discrete random data and its probability distribution. (PO–1,2 & PSO–2)
2. Find parameters of continuous probability distributions and calculate the marginal and conditional distributions of bivariate random variables. (PO-1, 2 & PSO –2)
2. Choose an appropriate test of significance and make inference about the population from a sample. (PO – 1, 2 & PSO –2)
3. Decide the type of experimental design suitable for a given situation and analyse the output.
4. (PO – 1, 2 & PSO – 2)
5. Apply Blocking and construct fractional factorial design. (PO – 1, 2 & PSO – 2)

Courses Assessment and Evaluation:

Continuous Internal Evaluation: 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	**Marks**	**Course outcomes addressed**
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

CHEMICAL REACTION ENGINEERING-I	
Course Code: CH42	**Credits: 3:0:1**
Pre – requisites: Chemical Process Calculations & Engineering Chemistry	**Contact Hours: 42L+14P**
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 (Uni-molecular and bimolecular type), Overall orders from half-life method. Reversible first order reactions Interpretation of batch reactor data by differential method of analysis.

- Pedagogy/Course delivery tools: Chalk and talk/ppt
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- 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
- Links: https://nptel.ac.in/courses/103107123
- Impartus recording: http://a.impartus.com/ilc/#/course/81470/295
- Laboratory session: RTD studies in flow reactors

Text Books:

1. Levenspeil, 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. Understand the types of reactions and the effect of temperature on the rate of reaction. (PO-1, PO-2, PSO-1, PSO-3)
2. Explain the methods for determining kinetics of a reaction. (PO-1, PO-2, PO-3, PO-4, PSO-1, PSO-3)
3. Develop expressions for batch, tubular and stirred tank reactors and evaluate rate equations. Compare the reactors and systems of multiple reactors. (PO-1, PO-2, PO-3, PO-4, PSO-1, PSO-3)
4. Find thermal characteristics of reactors and their usage in design procedure. (PO-1, PO-2, PO-3, PO-4, PSO-1, PSO-3)
5. Explain the extent of non-ideality in a reactor. (PO-1, PO-2, PO-3, PO-4, PSO-1, PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
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: CH43	**Credits: 2:1:0**
Pre – requisites: Engineering Mathematics	**Contact Hours: 28L+ 14T**
Course Coordinator: Dr. Archna	

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-zNYlY
- 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, PO-2, 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, PO-2, PO-3, PO-4, PSO-1, PSO-3)
3. Comprehend correlations of convective heat transfer, LMTD, heat transfer coefficients, boiling and condensation phenomena. (PO-1, PO-2, PO-3, PSO-1)
4. Design various types of heat exchangers and condensers. (PO-1, PO-3, PO-4, PSO-1, PSO-3)
5. Apprehend various types of evaporators and radiation heat transfer between surfaces. (PO-1, PO-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: CH44	**Credits: 2:1:0**
Pre – requisites: -	**Contact Hours: 28L+ 14T**
Course Coordinator: Dr. Ashwini Wali	

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: https://archive.nptel.ac.in/courses/103/103/103103034/
- Impartus recording: http://a.impartus.com/ilc/#/course/2583951/1205

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://archive.nptel.ac.in/courses/103/103/103103034/
- Impartus recording: http://a.impartus.com/ilc/#/course/2583951/1205

Unit III

Humidification: General theory. Psychometric 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://archive.nptel.ac.in/courses/103/103/103103034/
- Impartus recording: http://a.impartus.com/ilc/#/course/2583951/1205

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://archive.nptel.ac.in/courses/103/103/103103034/
- Impartus recording: http://a.impartus.com/ilc/#/course/2583951/1205

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://archive.nptel.ac.in/courses/103/103/103103034/
- Impartus recording: http://a.impartus.com/ilc/#/course/2583951/1205

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., Laksmikutty, 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, PO-2, PO-3, PSO-1)
2. Understand mass transfer coefficients, co-current, cross-current and counter-current operations. ((PO-1, PO-2, PSO-1)
3. Analyze stage wise operations and solve problems on humidification, dehumidification and drying. (PO-1, PO-2, PO-3, PSO-1)
4. Solve problems on crystallization and explain the types of crystallizers required for different crystallization process. (PO-1, PO-2, PSO-1, PSO-2)
5. Understand and analyze adsorption and ion exchange process. (PO-1, PO-2, PO-7, PSO-1, PSO-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

CHEMICAL ENGINEERING THERMODYNAMICS	
Course Code: CH45	**Credits: 2:1:0**
Pre – requisites: Nil	**Contact Hours: 28L+ 14T**
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. 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. Evaluate heat and work requirements for the given flow or non-flow processes. (PO-1, PO-2, PO-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, PO-2, PO-3, PSO-1, PSO-2)
3. Evaluate thermodynamic properties of pure fluids and partial molar properties in solution. (PO-1, PO-2, PO-3, PSO-1, PSO-2)
4. Generate Vapour Liquid Equilibrium data for ideal and non-ideal solutions and check for their consistency. (PO-1, PO-2, PO-3, PSO-1, PSO-2)
5. Evaluate the feasibility and extent of conversion for any reaction. (PO-1, PO-2, PO-3, PSO-1, PSO-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

POLLUTION CONTROL LABORATORY	
Course Code: CHL46	**Credits: 0:0:1**
Pre – requisites: Nil	**Contact Hours: 14P**
Course Coordinator: Sri. Sagar	

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. Settle able 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 COx, SOx, NOx 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, PO-3, PO-4, PO-6, PO-7, PO-8, PO-12, PSO-1, PSO-3)
2. Determine pollutants in air. (PO-2, PO-3, PO-4, PO-6, PO-7, PO-8, PO-12, PSO-1, PSO-3)
3. Use instruments to determine pollutant compositions. (PO-2, PO-3, PO-4, PO-6, PO-7, PO-8, PO-12, PSO-1, PSO-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: CHL47	**Credits: 0:0:1**
Pre – requisites: Nil	**Contact Hours: 14P**
Course Coordinator: Dr. Rama Sivakiran Reddy	

Course Content

1. Natural Convection in Bare and Finned tube
2. Vertical Shell and Tube Heat exchanger (Condenser)
3. Horizontal Shell and tube Heat exchanger (Condenser)
4. Helical Coil Heat Exchanger
5. Emissivity Determination
6. Effect of Geometry on Natural Convection
7. Heat Transfer in Packed Beds
8. Double Pipe Heat Exchanger
9. Heat Transfer in Jacketed Vessel
10. Determination of Insulation Thickness
11. Transient Heat Conduction
12. Heat Transfer in Fluidized Beds
13. Evaporator
14. Solar Heater
15. Spiral Plate Heat Exchanger
16. 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, PO-2, PO-3, PSO-1, PSO-3)
2. Evaluate the performance of different types of heat exchangers. (PO-1, PO-2, PO-3, PSO-1, PSO-3)
3. Explain the necessity of insulation and fins. (PO-1, PO-2, PO-3, PSO-1, PSO-3)

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: CHL48	**Credits: 0:0:1**
Pre – requisites: Engineering Graphics	**Contact Hours: 14P**
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, PO-2, PO-3, PO-5, PSO-1, PSO-2)
2. Show details of Process Equipment through Drawings. (PO-1, PO-2, PO-3, PO-5, PSO-1, PSO-2)
3. Draw P&ID for chemical operations. (PO-1, PO-2, PO-3, PO-4, PO-5, PSO-1, PSO-2)

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

ABILITY ENHANCEMENT COURSE – IV INDUSTRIAL POLLUTION CONTROL AND SAFETY	
Course Code: CHAEC49	**Credits: 1:0:0**
Pre – requisites: Engineering Chemistry, Environmental Studies	**Contact Hours: 14L**
Course Coordinator: Sri. Sagar J S	

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.

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.

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.

Unit V

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

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-1,6,7, PSO-1)
2. Understand waste water treatment technologies depending on the type of industrial waste waters. (PO-1, 6, 7, PSO-1)
3. Identify the sources of air pollution by carrying out air sample analysis and suggest schemes for its prevention. (PO-1, 6, 7, PSO-1)
4. Understand concept of safety and safety devices. (PO-1, 6, 7,12, PSO-1)
5. Apply techniques for process safety analysis. (PO-1, 6, 7,12, PSO-1)

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ADDITIONAL MATHEMATICS - II	
Course Code: AM41	**Credits: 0:0:0**
Pre – requisites: Nil	**Contact Hours: 28L**
Course Coordinator: Dr. Veena B N	

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
- Online tools: Use of open source software's to demonstrate methods and solve problems on interpolation
- 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
- Online tools: Use of open source software's to demonstrate methods and solve problems on numerical differentiation and integration.
- 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/619570/1030

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