AISSMS
COLLEGE OF ENGINEERING
ज्ञानम् सकलजनहिताय
An Autonomous Institute Affiliated with
Savitribai Phule Pune University
Accredited by NAAC with "A+" Grade | NBA - 7 UG Programmes

Savitribai Phule Pune University

All India Shri Shivaji Memorial Society's

COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute Affiliated to Savitribai Phule Pune University, Pune)

Faculty of Science and Technology

Curriculum Structure and Syllabus

M. Tech. Chemical Engineering (2025 Pattern)

(With effect from Academic Year 2025-26)

www.aissmscoe.com

M. Tech. Chemical Engineering (2025 Pattern)
ABBREVIATIONS

Abbreviation	Title	Abbreviation	Title
PSM	Program Specific Mathematics Course	OE	Open Elective
PSB	Program Specific Bridge Course	SLC	Self-Learning Course
PCC	Program Core Course	AEC	Ability Enhancement Course
PEC	Program Specific Elective Course	MLC	Mandatory Learning Course
LC	Laboratory Course	CCA	Co-curricular & Extracurricular Activities
VSE	Vocational and Skill Enhancement Course		

M. Tech. Chemical Engineering (2025 Pattern)

Distribution of Credits

S.N.	Course Type	Course Title	No. of Credits (Semester wise)				Credits	
			I	II	III	IV	Total	%
1	PSM	Program Specific Mathematics Course	04	--	--	--	04	4.54
2	PSB	Program Specific Bridge Course	04	--	--	--	04	4.54
3	PCC	Program Core Course	12	08	--	--	20	22.72
4	LC	Laboratory Course	02	02	--	--	04	4.54
5	MLC	Mandatory Learning Course	--	--	04	04	08	9.09
6	PEC	Program Specific Elective Course	--	04	--	--	04	4.54
7	AEC	Ability Enhancement Course	--	04	--	--	04	4.54
8	OE	Open Elective	--	04	--	--	04	4.54
9	VSE	Vocational and Skill Enhancement Course	--	--	14	12	26	29.54
10	SLC	Self-Learning Course	--		04	04	08	9.09
11	CCE	Co-curricular & Extracurricular Activities	--	--	--	02	02	2.72
			22	**22**	**22**	**22**	**88**	**100**

M. Tech. Chemical Engineering (2025 Pattern)
Curriculum Structure: Semester I

Sr. No.	Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						
				L	P	CCA		ESE	TW	OR	Total	Credits
						Activities	MSE					
1	PSM501CEE	PSM	Process Optimization	**4**	**-**	**20**	**30**	**50**	**-**	**-**	**100**	**4**
2	PSB511CEE	PSB	Biochemical Engineering	**4**	**-**	**20**	**30**	**50**	**-**	**-**	**100**	**4**
3	PCC521CEE	PCC	Advanced Mass Transfer	**4**	**-**	**20**	**30**	**50**	**-**	**-**	**100**	**4**
4	PCC522CEE	PCC	Advanced Separation Techniques	**4**	**-**	**20**	**30**	**50**	**-**	**-**	**100**	**4**
5	PCC523CEE	PCC	Advanced Chemical Reaction Engineering	**4**	**-**	**20**	**30**	**50**	**-**	**-**	**100**	**4**
6	LC531CEE	LC	Chemical Lab – I	**-**	**4**	**-**	**-**	**-**	**25**	**25**	**50**	**2**
7	MLC541DES (***Non-Credit***)	MLC*	Communication Skill and Personality Development	**2**	**-**	**20**	**30**	**-**	**-**	**-**	**50**	**-**
	Total			**22**	**4**	**120**	**180**	**250**	**25**	**25**	**600**	**22**

L: Lecture**, P:** Practical**, CCE:** Comprehensive Continuous Evaluation**; MSE:** Mid Semester Examination; **ESE:** End Semester Examination**; TW:** Term Work**, OR:** Oral Examination; * Common to all programs

M. Tech. Chemical Engineering (2025 Pattern)

Curriculum Structure: Semester II

Sr. No.	Course Code	Course Type	Course Name	Teaching Scheme L	Teaching Scheme P	Examination Scheme CCA Activities	CCA MSE	ESE	TW	OR	Total	Credits
1	PCC524CEE	PCC	Advanced Transport phenomena	4	-	20	30	50	-	-	100	4
2	PCC525CEE	PCC	Advanced Process Control	4	-	20	30	50	-	-	100	4
3	PEC551CEE	PEC	Program Specific Elective	4	-	20	30	50	-	-	100	4
4	LC532CEE	LC	Chemical Lab – II	-	4	-	-	-	25	25	50	2
5	AEC561DES	AEC	Research Methodology and IPR	4	-	20	30	50	-	-	100	4
6	OE571CEE	OE	Open Elective	4	-	20	30	50	-	-	100	4
7	MLC542DES (*Non Credit*)	MLC*	Sustainable Engineering and Circular Economy	2	-	20	30	-	-	-	50	-
	Total			**22**	**4**	**120**	**180**	**250**	**25**	**25**	**600**	**22**

L: Lecture, **P:** Practical, **CCE:** Comprehensive Continuous Evaluation**; MSE:** Mid Semester Examination; **ESE:** End Semester Examination**; TW:** Term Work**, OR:** Oral Examination; * Common to all programs

Program Specific Elective Course (Select any ONE)			
Course Code	**Title**	**Course Code**	**Title**
PEC551ACEE	AI & Data Science in Chemical Engineering	PEC551CCEE	Chemical Safety and Risk Management
PEC551BCEE	Advanced Wastewater Treatment and Emerging Technologies	PEC551DCEE	Advanced Project Management Techniques

Open Elective Course (Select any ONE)			
Course Code	**Title**	**Course Code**	**Title**
OE573CON	Organizational Ethics and Human Resource Management	OE573STR	Financial Management
OE571CEE	Economics of innovation	OE571PED	Entrepreneur Development

M. Tech. Chemical Engineering (2025 Pattern)
Curriculum Structure: Semester III

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits
			L	P	CCA		ESE	TW	OR	Total	
					Activities	MSE					
VSE611CEE	VSE	Dissertation Phase -I	-	12	-	-	-	100	50	150	6
SLC621CEE	SLC	Massive Open Online Course I	4	-	-	-	-	100	-	100	4
VSE612CEE	VSE	Internship / On Job Training	-	16	-	-	-	100	100 -	200	8
MLC643AID	MLC*	Human Rights	2	-	20	30	-	-	-	50	2
MLC602DES	MLC*	Introduction to Constitution	2	-	20	30	-	-	- -	50	2
Total			**8**	**28**	**40**	**60**	**-**	**300**	**150**	**550**	**22**

L: Lecture, P: Practical, **CCA**: Comprehensive Continuous Assessment; **MSE**: Mid Semester Assessment; **ESE**: End Semester Examination; **TW**: Term Work, **OR**: Oral Examination, * Common to all programs

M. Tech. Chemical Engineering (2025 Pattern)
Curriculum Structure: Semester IV

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits
			L	P	CCA		ESE	TW	OR	Total	
					Activities	MSE					
VSE613CEE	VSE	Dissertation Phase -II	-	24	-	-	-	200	100	300	12
SLC622CEE	SLC	Massive Open Online Course II	4	-	-	-	-	100	-	100	4
CCA631CEE	CCA	Seminar / Paper presentation in Conference/Patent Filing/Copyright	-	4	-	-	-	25	25	50	2
MLC672AID	MLC*	Introduction to cyber security	4		20	30	50	-	-	100	4
Total			8	28	20	30	50	325	125	550	22

L: Lecture, P: Practical, **CCA**: Comprehensive Continuous Assessment; **MSE**: Mid Semester Assessment; **ESE**: End Semester Examination; **TW**: Term Work, **OR**: Oral Examination, * Common to all programs

***CONTINUOUS COMPREHENSIVE ASSESSMENT (CCA)**

The continuous and comprehensive assessment (CCA) will be carried out in two parts:

(A) Activities: 20 Marks (Any TWO)

(i) Field Visit	(iii) Case Study	(v)Technical report on advance topic
(ii) Research Note	(iv) Simulation	

Guidelines:

SN	Activity	Requirements	Evaluation Criteria (Marks out of 10)
1	**Field Visit**	• Participate in at least one relevant industrial/field visit. • Submit a report with objectives, observations, process details, and analysis linking theory to practice. • The report should include relevant photographs, sketches, or process flow diagrams.	• Report content quality and technical depth– 4 • Depth of analysis & observations – 4 • Presentation and formatting– 2
2	**Research Note**	• Select a current research problem in Chemical Engineering. • Prepare a research note with background, literature review (min. 10 references), and research idea, methodology outline, or design approach • Follow Elsevier/Springer citation style.	• Literature review quality – 4 • Originality & relevance – 4 • Academic writing & formatting – 2
3	**Case Study**	• Select a case involving design failure, optimization, sustainability or innovation. • Submit a report with problem statement, technical analysis (calculations/simulations), and recommendations/conclusions.	• Problem clarity & technical accuracy – 3 • Analytical depth & methodology – 5 • Presentation & structure – 2
4	**Simulation**	• Use software (ANSYS, DWSIM/ UniSIM, MATLAB, Fluent etc.). • Report must include problem definition, modeling approach, assumptions, results, and interpretation. • Submit simulation files for evaluation.	• Accuracy of model setup – 4 • Quality of results & interpretation – 4 • Report clarity – 2
5	**Technical Report on Advanced Topic**	• Select an advanced/emerging topic • Prepare a word report with technical details, applications, challenges, and future scope. • Include at least 10-15 recent references from peer reviewed journals (past 5 years).	• Technical depth & coverage – 4 • Critical analysis & insight – 4 • Presentation & formatting – 2

(B) Mid Semester Evaluation (MSE)

(i)	Class Test – I	Unit I	15 Marks
(ii)	Class Test – II	Unit II	15 Marks

END Semester Examination (ESE)

Examination will be carried out on unit 3,4 and 5 carrying following marks weightage:

Unit No.	Marks Weightage
Unit III	16
Unit IV	17
Unit V	17

DISSERTATION WORK:

The dissertation work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

Dissertation Phase – I

Dissertation Phase – I is the integral part of the project Work. In this, the student shall complete the partial work of the Project that will consist of problem statement, literature review, project overview, scheme of implementation (UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. The candidate shall deliver a presentation as a part of the progress report of Project work Stage-I, on the advancement in Technology pertaining to the selected dissertation topic. The student shall submit the progress report of Project Work Stage-I in standard format duly certified for satisfactory completion of the work by the concerned guide. The report must undergo plagiarism screening using anti-plagiarism software, and the similarity index shall not exceed 25%.

Dissertation Phase – II

In Dissertation Phase – II, the student shall complete the balance part of the Project that will consist of fabrication of set up required for the project, conducting experiments and taking results, analysis & validation of results and conclusions.

The student shall prepare the final report of Project work in standard format duly certified for satisfactory completion of the work by the concerned guide. The dissertation must undergo plagiarism screening using anti-plagiarism software, and the similarity index shall not exceed 25%. It is mandatory to publish **one paper in conference** and **one paper in peer reviewed journal** before submission of the dissertation.

MOOC COURSE SELECTION AND EVALUATION GUIDELINES:

Students shall select a MOOC course related to current trends in their respective engineering discipline, preferably aligned with their area of specialization. The course must be at the postgraduate level and should be selected in consultation with the assigned guide and approved by the designated authority. It may be taken from recognized MOOC platform such as NPTEL. Students are required to submit hard copies of all course assignments. The student is expected to register for the examination and obtain the certificate from competent authority.

Evaluation Guidelines: Students will be evaluated progressively for a total 100 Marks.

Sr. No.	Parameter	Marks
1	Presentation of the Selected topic	20
2	Assignment Scores	50 (The total marks obtained in the assignments shall be proportionally converted to an equivalent score out of 50.)
3	Certification Granted Based on the MOOC Provider's Examination	30
Total Marks		**100**

INTERNSHIP/ ON JOB TRAINING:

Each student shall undertake an internship/ On job training of **8–10 weeks** in an industry, research institute, or consultancy firm under the guidance of an allocated faculty supervisor. The faculty guide shall be responsible for monitoring and evaluating the student's progress, in coordination with the industry/research supervisor.

Students must maintain a detailed project diary recording tasks performed, data collected, observations made, and challenges encountered. Progress shall be demonstrated through regular reporting, presentations, and proper documentation. The student is required to meet with the institute supervisor fortnightly to discuss and record progress.

Three progress reviews will be conducted during the internship:

Review–I: Understanding of the organization, assigned tasks, and work plan. (20 Marks)
Review–II: Mid-term progress, skill application, and problem-solving approach. (20 Marks)
Review–III: Completion status, demonstration of outcomes, and final feedback. (20 Marks)
The documentation comprising training report, project diary will carry 40 Marks.

Upon completion, the student shall submit a comprehensive internship report summarizing skills acquired, activities undertaken, challenges faced, and results achieved. A completion certificate from the host organization is mandatory. The final evaluation will be based on the internship report, feedback from the industry/research guide, and an oral examination.

Exit option to qualify for PG Diploma in Chemical Engineering: 12-14 Weeks domain specific industrial internship after successfully completion of first year of the program.

Course Syllabus

Semester-I

Semester I

PSM501CEE: Process Optimization

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>PSM501CEE</td><td>4</td><td>50</td><td>50</td><td>--</td><td>--</td><td>100</td><td>4</td></tr>
</table>

<table>
<tr><td>Course Objectives:</td><td>• To study Formulation of optimization problems and main solution techniques
• To formulate algorithms of numerical methods of optimization
• To understand the impact of optimization in areas like process design, process control, etc.
• To provide an overview of state-of-the-art optimization techniques in chemical Engineering</td></tr>
<tr><td>Course Outcomes:</td><td>• Understand the fundamentals and classification of process optimization problems.
• Apply optimization techniques to one-dimensional functions using search and gradient methods.
• Use multivariable optimization algorithms for unconstrained optimization problems.
• Solve constrained optimization problems using classical and modern methods.
• Implement non-linear programming techniques for complex chemical process optimization.</td></tr>
<tr><td rowspan="2">Course Contents:</td><td>UNIT I Introduction (10 Hrs)
Introduction to process optimization, formulation of various process optimization problems (Nature and scope of optimization, general procedure for solving optimization problems) and their classification, Basic concepts of optimization: Continuity of function, unimodal and multimodal function, convex and concave function, necessary and sufficient conditions for stationary points.</td></tr>
<tr><td>UNIT II Optimization of One-Dimensional Functions (10 Hrs)
Unconstrained multivariable optimization- direct search methods, Bracketing methods: Exhaustive search method, Bounding phase method, Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method.</td></tr>
</table>

	Indirect first order and second order method. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cubic search method. Root-finding using optimization Techniques
	UNIT III Multivariable Optimization Algorithms (10 Hrs) Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method.
	UNIT IV Constrained Optimization Algorithms (11 Hrs) Basic concepts, simplex method, revised simplex method, Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Sensitivity analysis, Direct search for constraint minimization: Variable elimination method, complex search method.
	UNIT V Non-linear programming (11 Hrs) The Lagrange multiplier method, quadratic programming, reduced gradient method, random search method, successive linear and quadratic programming, optimization of staged and discrete processes, optimization of dynamic processes.
Reference Books:	• Deb K. "Optimization for engineering design: Algorithms and Examples", Prentice Hall of India, New Delhi, 1995 • Edgar T. F., Himmelblau D. M. and Ladson, "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003

PSB511CEE: Biochemical Engineering

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
PSB511CEE	4	50	50	--	--	100	4

Course Objectives:	• Understand microbial cell structure, classification, and growth kinetics. • Learn different bioreactor designs, fermentation operations, and scale-up principles. • Study enzyme classification, kinetics, inhibition, and immobilization techniques. • Understand downstream processing methods for recovery and purification of bioproducts. • Explore industrial applications, emerging technologies, and bioprocess control in biochemical engineering.
Course Outcomes:	• Explain microbial cell types and model microbial growth in batch, fed-batch, and continuous cultures. • Describe bioreactor components, sterilization methods, aeration, agitation, and scale-up challenges. • Analyse enzyme kinetics and inhibition, and apply enzyme immobilization in industrial processes. • Demonstrate knowledge of cell disruption and separation techniques for product recovery and purification. • Identify applications of biochemical engineering in metabolite production, biofuels, bioremediation, and bioprocess control.
Course Contents:	**UNIT I Introduction to Biochemical Engineering (10 hrs)** Scope and significance of biochemical engineering, Structure and functions of microbial cells, Classification of microorganisms, Microbial growth kinetics: Batch, Fed-batch, and Continuous cultures, Monod equation and growth models (substrate inhibition, product inhibition)
	UNIT II Bioreactors and Fermentation Technology (10 hrs) Overview of bioreactors: Stirred tank, airlift, packed bed, fluidized bed, Components and operation of a fermenter, Sterilization techniques: batch and

	continuous, Aeration and agitation: oxygen transfer, kLa, oxygen balance, Scale-up criteria and challenges in aerobic and anaerobic fermentation
	UNIT III Enzyme Technology (10 hrs) Classification and properties of enzymes, Enzyme kinetics: Michaelis-Menten model, Inhibition kinetics: competitive, non-competitive, uncompetitive, Immobilization of enzymes: methods and applications, Industrial applications of enzymes in food, pharmaceutical, and textile industries
	UNIT IV Downstream Processing (11 hrs) Introduction to product recovery and purification, Cell disruption methods: mechanical and non-mechanical, Separation techniques: centrifugation, filtration, sedimentation, Purification techniques: chromatography, precipitation, ultrafiltration, Drying and crystallization of biochemical products
	UNIT V Applications and Emerging Areas (11 hrs) Production of primary and secondary metabolites: alcohols, antibiotics, amino acids, Bioprocessing for biofuels, bioplastics, and biosurfactants, Bioremediation and wastewater treatment, Introduction to metabolic engineering and synthetic biology, Bioprocess control and instrumentation basics
Reference Books:	• Bailey, J. E. and Ollis, D. F., Biochemical Engineering Fundamentals, McGraw-Hill • Shuler, M. L. and Kargi, F., Bioprocess Engineering: Basic Concepts, Prentice Hall

PCC521CEE: Advanced Mass Transfer

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
PCC521CEE	4	50	50	--	--	100	4

Course Objectives:	• Understand multicomponent and non-ideal mass transfer phenomena and models. • Analyze mass transfer coupled with chemical reactions in multiphase systems. • Design and model advanced separation processes including membranes and adsorption. • Apply design and scale-up principles for mass transfer equipment. • Use modelling and simulation tools for mass transfer and explore recent developments.
Course Outcomes:	• Explain and apply multicomponent diffusion theories and non-ideal mass transfer concepts in porous and catalyst media. • Evaluate mass transfer with chemical reactions, calculate enhancement factors, and design absorption processes involving reactions. • Design and analyze advanced distillation, membrane separation, and adsorption processes with real industrial applications. • Develop detailed designs of mass transfer equipment, addressing scale-up challenges and process intensification techniques. • Utilize numerical and simulation methods for mass transfer modelling and assess recent technological advancements in the field.
Course Contents:	**UNIT I Multicomponent and Non-Ideal Mass Transfer (10 Hrs)** Multicomponent diffusion: Maxwell-Stefan equations, generalized Fick's Law, coupled mass and heat transfer, mass transfer in non-ideal and anisotropic systems, Diffusion in catalysts and porous media, Theories of mass transfer: film, penetration, surface renewal models revisited
	UNIT II Interfacial Mass Transfer and Chemical Reaction (10 hrs) Gas-liquid and liquid-liquid mass transfer with simultaneous chemical reaction, Enhancement factors and Hatta number analysis, Mass transfer regimes: slow, fast, and instantaneous reactions, Absorption with chemical reaction: design

	implications, Case studies: CO_2 absorption, flue gas desulfurization, reactive extraction
	UNIT III Advanced Separation Processes (10 hrs) Design and modeling of advanced distillation: extractive, azeotropic, pressure-swing, Reactive distillation and absorption, Membrane separation: theory, models, and module design, Adsorption: kinetics, isotherms, dynamic column behavior (breakthrough curves), Hybrid separations: membrane-distillation, reactive extraction
	UNIT IV Mass Transfer Equipment Design and Scale-up (11 hrs) Design of packed/tray columns using HTU/NTU and mass transfer coefficient approach, Scale-up considerations: residence time distribution, mal-distribution, non-ideal flow, Structured packing: performance evaluation and scale-up, Mass transfer intensification using rotating packed beds, ultrasound, microwaves, Design of PSA/VSA/MB absorbers
	UNIT V Modeling, Simulation, and Recent Developments (11 hrs) Numerical methods in diffusion and mass transfer modeling (FEM, FDM), Use of process simulation tools (Aspen Plus, COMSOL, MATLAB), Population balance modeling in crystallization, drying, leaching, CFD in mass transfer equipment, Recent trends: process intensification, bio - separations, green solvents, nanostructured adsorbents
Reference Books:	• Geankoplis, C. J., *Transport Processes and Separation Process Principles*, Prentice Hall • Krishna, R., Wesselingh, J. A., *Mass Transfer: Principles and Applications*, Wiley

PCC522CEE: Advanced Separation Techniques

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
PCC522CEE	4	50	50	--	--	100	4

Course Objectives:	• To familiarize students with various advanced aspects of separation processes and the selection of separation processes. • To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation. • To introduce them to new trends used in the separation technologies
Course Outcomes:	• Understand advanced principles and applications of conventional and emerging separation techniques. • Analyse and design membrane-based separation systems for liquid and gas applications. • Apply adsorption and chromatographic methods for separation and purification processes. • Evaluate ionic separation techniques and their industrial applications. • Explore and assess novel separation methods for complex industrial and environmental problems.
Course Contents:	**UNIT I Introduction to Separation Processes (10 Hrs)** Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and equipment used in cross flow filtration, cross flow electro filtration, dual functional filter, Surface based solid - liquid separations involving a second liquid, Sirofloc filter.

	UNIT II Membrane Separations (10 hrs) Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Design aspects of Nanofiltration, Ultrafiltration, Microfiltration and Donnan dialysis, Design aspects of Pervaporation and Permeation techniques for liquids and gases, Ceramic Membranes.
	UNIT III Separation by Adsorption Techniques (10 hrs) Mechanism, Types and choice of adsorbents, adsorption techniques, HPLC, GPC, HPTLC techniques of analytical separation, Recent Advances and Process Economics of Analytical Separation., Reactive absorption for removal of hazardous gases like H_2S, SO_X etc.
	UNIT IV Ionic Separations (11 hrs) Controlling factors, Applications, Types of equipment employed for electrophoresis, Di-electrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes.
	UNIT V Auxiliary Techniques (11 hrs) Reactive separation processes - Reactive extraction and distillation, Separations involving Lyophilization, Industrial viability and Examples, Zone melting, Adductive crystallization, Supercritical fluid extraction, Ultrasound and Microwave assisted extraction, Oil spill Management, Industrial effluent treatment by modern techniques, Foam Separation technique.
Reference Books:	• Lacey, R.E. and Loaeb S. - “Industrial Processing with Membranes", Wiley –Interscience, New York, 1972. • King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd., 1982.

PCC523CEE: Advanced Chemical Reaction Engineering

CODE	TEACHING SCHEME	EXAMINATION SCHEME						CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total		
		CCA	ESE					
PCC523CEE	**4**	**50**	**50**	**--**	**--**	**100**		**4**

Course Objectives:	• To understand catalytic and non-catalytic reaction mechanisms and apply kinetic models to heterogeneous systems. • To study residence time distribution and develop models for non-ideal flow in chemical reactors. • To analyse the impact of external mass and heat transfer on heterogeneous reaction rates. • To evaluate the effectiveness factor considering intraparticle diffusion and heat transfer in porous catalysts. • To design various types of multiphase and fixed-bed reactors considering heat and mass transfer effects.
Course Outcomes:	• Analyze reaction kinetics for catalytic and non-catalytic heterogeneous systems using mechanistic models. • Apply population balance and residence time distribution concepts to characterize non-ideal reactors. • Evaluate the effects of external mass and heat transfer limitations on reaction performance. • Determine the effectiveness factor considering internal diffusion and reaction within porous catalysts. • Design and analyze catalytic and multiphase reactors for industrial chemical processes.
Course Contents:	**UNIT I Kinetics of Heterogeneous Reactions (10 Hrs)** Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Rideal – Eiley Mechanism, Steady State approximation, Noncatalytic fluid - solid reactions, Shrinking and unreacted core model.
	UNIT II Population Balance Models (10 hrs)

	Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of nonideal reactors.
	UNIT III External Diffusion Effects in Heterogeneous Reactions (10 hrs) Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.
	UNIT IV Internal Transport Processes in Porous Catalysts (11 hrs) Intra-pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.
	UNIT V Design of Heterogeneous Catalytic Reactors (11 hrs) Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors. Introduction to multiphase reactor design, Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model.
Reference Books:	• Smith J.M. - "Chemical Engineering Kinetics ", McGraw-Hill, 1981 • Bischoff and Froment - " Chemical Reactor Design and Analysis ", Addision – Wesley, 1982

LC531CEE: Chemical Lab – I

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr. Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
LC531CEE	**4**	**--**	**--**	**25**	**25**	**50**	**2**

Course Objectives:	• To familiarize students with modelling, simulation, and scale-up challenges in multiphase reactors. • To develop students to real-world case studies and recent advancements in multiphase reactor technologies. • To familiarize students with downstream processing techniques for product recovery, purification and bioremediation. • To equip students with skills in applying AI for process control, fault detection, predictive maintenance, and optimization. • To familiarize students with cutting-edge AI technologies such as digital twins, hybrid modelling, and smart manufacturing relevant to Industry 4.0. • To introduce modelling and simulation techniques in mass transfer, including numerical methods, CFD, and process intensification.
Course Outcomes:	After successful completion of the course, learner will be able to: • Analyze flow patterns and transport phenomena in multiphase environments using software tools. • Apply various process control strategies in diversified Chemical Engineering operations. • Demonstrate knowledge of downstream processing techniques for efficient product recovery. • Apply AI tools to develop soft sensors, perform fault detection, and carry out process optimization. • Develop numerical models and simulations of diffusion and separation processes using tools such as MATLAB, DWSIM, and EXCEL.
Course Contents:	**Important instructions:** The students are required to preserve the samples, compounded materials, test specimens, tested specimens, 'original' result papers such as charts, graphs, data sheets soft copies of modelling and analysis etc. and

	should be submitted along with the journal for evaluation failing which the TW will not be granted. The laboratory work will be based on completion of assignments confined to the courses of that semester. The assessment will be done jointly by the pair of internal and external examiners along with the oral examination of the same. Each student should perform **at least 08 experiments from the following list** and submit the journal which will form the term-work for the subject. **Important Note:** • **Each experiment is to be supported with compulsory assignment which should be the part of the journal.** • **Study experiments are strictly avoided as Chemical Lab – I experiment.** **List of experiments** • Simulate different flow regimes and analyze transitions using superficial gas velocity. • Model RTD curves for plug flow and stirred multiphase reactors and interpret dispersion. • Evaluate the effect of diffusion resistance on catalyst effectiveness for gas-solid systems. • Simulate the impact of liquid velocity and particle diameter on transfer coefficients. • Compare reaction rates using intrinsic and apparent kinetics models. • Design a gas-liquid reactor (e.g., hydrogenation) with phase equilibria, kinetics, and sizing. • Use empirical and theoretical correlations to model pressure drop and compare configurations. • Simulate the deactivation and regeneration cycles and observe changes in conversion over time. • Model the dynamic behavior of a fermentation process including gas-liquid mass transfer and biomass kinetics. • Simulate microbial growth using Monod and inhibition models; compare productivity in different culture modes. • Analyze the effect of agitation and aeration on oxygen transfer in stirred tank reactors.

	- Simulate Michaelis-Menten kinetics and different inhibition types (competitive, non- competitive, etc.). - Simulate a continuous bioreactor for alcohol/antibiotic production, including basic reactor sizing and flow parameters. - Develop a fed-batch model with substrate and product inhibition to optimize metabolite yield. - Model adsorption, elution, and recovery profiles for a target protein or enzyme. - Simulate a feedback loop for controlling pH, temperature, or dissolved oxygen in a bioreactor. - Implement linear regression models to predict product yield or conversion in a reactor using experimental data. - Use a simple algorithm to develop the control strategies that maximize product concentration in a batch reactor simulation. - Simulate a distillation column in DWSIM or any suitable software to predict tray temperatures or composition profiles based on operating data. - Simulate a continuous stirred tank reactor using sensor data emulation using suitable software. - Analyze performance, fault detection, and predictive maintenance strategies. Use any suitable software. - Model a fused deposition modelling (FDM) process for a simple component. - Evaluate layer thickness, deposition speed, and mechanical strength. - Simulate interactive walkthroughs of equipment with guided operating procedures. **Any other simulation experiment/s in consultation with teaching faculty**
Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus. It is to be submitted as term work at the end of semester after continuous assessment of each by respective teacher.	

Semester I

MLC541DES: Communication Skills and Personality Development

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
MLC541DES (*Non-credit*)	**2**	**50**	**--**	**--**	**--**	**50**	**-**

Course Objectives:	• Demonstrate proficiency in verbal and written communication across professional settings. • Improve self-awareness and emotional intelligence for effective interpersonal relationships. • Exhibit confidence, adaptability, and leadership in individual and team contexts. • Apply principles of non-verbal, cross-cultural, and digital communication effectively. • Prepare for job interviews, public speaking, and professional presentations with competence.
Course Outcomes:	Upon completion of the course, students will be able to: • Apply communication principles to enhance clarity and effectiveness in professional contexts. • Demonstrate proficiency in formal written and digital communication. • Develop self-awareness and manage personal growth through emotional intelligence. • Exhibit interpersonal skills for effective teamwork, leadership, and conflict resolution. • Prepare and present professional content confidently using verbal and non-verbal strategies.
Course Contents:	**UNIT I Fundamentals of Communication (06 Hrs)** Elements and Process of Communication, Types: Verbal, Non-Verbal, Written, Visual, Barriers to Communication & Overcoming Strategies, Listening Skills & Feedback Mechanisms, Communication in Multicultural Work Environments

	UNIT II Written and Digital Communication (06 Hrs) Professional Email Writing, Reports, Memos, and Proposals, Resume and Cover Letter Writing, Technical Writing for Engineers (Abstracts, Papers, Manuals), Digital Communication Etiquette (WhatsApp, LinkedIn, MS Teams), Use of AI and Tools in Business Communication
	UNIT III Personality Development and Self-Awareness (06 Hrs) Self-Concept, SWOT Analysis, Johari Window, Emotional Intelligence and Self-Regulation, Goal Setting, Motivation, Time Management, Stress Management and Mindfulness, Values, Ethics, and Personal Branding
	UNIT IV Interpersonal and Group Communication (6 Hrs) Interpersonal Relationship Building, Team Dynamics and Conflict Resolution, Negotiation and Assertiveness Skills, Public Speaking and Presentation Skills, Leadership and Decision-Making Styles
	UNIT V Career Readiness and Professional Communication (Written) (6 Hrs) Interview Preparation and Techniques (HR/Technical), Body Language, Dress Code, and Workplace Etiquette, Presentation with PowerPoint and Visual Aids, Elevator Pitch and Professional Introductions, Networking Skills and Professional Social Media Use
Reference Books:	• Meenakshi Raman & Sangeeta Sharma – Technical Communication: Principles and Practice, Oxford University Press • Barun K. Mitra – Personality Development and Soft Skills, Oxford University Press • Stephen R. Covey – The 7 Habits of Highly Effective People • Carnegie Dale – How to Win Friends and Influence People • Deborah J. Barrett – Business and Professional Communication
e-source:	• https://onlinecourses.nptel.ac.in/noc22_hs77 • https://onlinecourses.swayam2.ac.in/cec25_cm08 • https://onlinecourses-archive.nptel.ac.in/noc17_hs02

Course Syllabus

Semester - II

Semester II

PCC524CEE: Advanced Transport Phenomena

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="6">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>PCC524CEE</td><td>4</td><td>50</td><td>50</td><td>--</td><td>--</td><td>100</td><td>4</td></tr>
</table>

<table>
<tr><td>Course Objectives:</td><td>
• To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
• To enable students to understand the equations of change for isothermal flow and for non-isothermal flow.
• To introduce them details of equations of change for multi component systems
• 4. To give them insight into properties of two-dimensional flows and aspects of dimensional Analysis</td></tr>
<tr><td>Course Outcomes:</td><td>Upon completion of the course, students will be able to:
• Apply shell balances and equations of change to analyse classical fluid flow problems under isothermal and non-isothermal conditions.
• Differentiate between Newtonian and non-Newtonian fluids and describe their rheological behaviour in various flow systems.
• Formulate and solve continuity, momentum, and energy equations for multicomponent systems, including binary mixtures and diffusion problems.
• Analyse two-dimensional flow phenomena including creeping flow, inviscid flow, boundary layers, and turbulence with appropriate turbulence models.
• Utilize dimensional analysis and analogies among momentum, heat, and mass transfer to solve complex transport problems.</td></tr>
<tr><td rowspan="2">Course Contents:</td><td>UNIT I Basic concepts and vector mathematics (10 Hrs)

Basic concept and review of classical flow problems using shell balances. Review of mathematics Scalar, Vectors, Tensors, divergence partial derivative, substantial derivative, total derivative.</td></tr>
<tr><td>UNIT II The equations of change for isothermal flow (10 Hrs)

Equations of continuity, equation of motion, the equation of mechanical energy, non-Newtonian fluids. Newton’s low of viscosity, Non-Newtonian fluids, Rheological behavior of Non-newtonian fluid, The equations of change for non-isothermal flow, Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems. Basic concept and review of classical flow problems using shell balances.</td></tr>
</table>

	UNIT III The equations of change for multi component systems (10 Hrs) The equations of continuity for a binary mixture, the equation of continuity of A in curvilinear coordinates, the multicomponent equations of change in terms of the flows, the multi component fluxes in terms of the transport properties, use of equations of change to setup diffusion problems. Macroscopic Balances for Multicomponent Systems Mass, momentum and energy Balances Velocity, temperature and concentration distributions with more than one independent variables, unsteady flow, stream function, potential flow, boundary layer theory, steady state two dimensional flow for momentum, heat and mass.
	UNIT IV Two-dimensional flows (11 Hrs) Stream function. Limiting cases: Creeping flow, Inviscid flow, Boundary layer theory, turbulent flow: Transition to turbulence, Turbulence models. Introduction, fluctuations and time smoothened equations for velocity, temperature and concentration, time smoothing of equation of change, equation of energy, equation of continuity of A, Reynolds stresses. Turbulence in pipe flow, stirred vessels, fluidized beds and bubble columns.
	UNIT V Dimensional Analysis (11 Hrs) Introduction, momentum, heat and mass transfer, Analogy between heat, mass and momentum transfer, Reynolds analogy, Chilton & Colburn J factor analogy.
Reference Books:	1. Bird R.B., Stewart W.E. and Lightfoot E.N., “Transport Phenomena”, Wiley international Edition, New York 2002 2. Batchelor G.K., “An Introduction to Fluid Dynamics”, Cambridge University Press, Cambridge, 1967

Semester II
PCC525CEE: Advanced Process Control

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>PCC525CEE</td><td>4</td><td>50</td><td>50</td><td>--</td><td>--</td><td>100</td><td>4</td></tr>
</table>

<table>
<tr><td>Course Objectives:</td><td>

To establish control-relevant process model using first-principle, and empirical approaches
To design complex control structures for processes with difficult dynamics
To analyze and design multi-loop (MIMO) control systems
To understand discrete-time control systems
Applications of advanced process control systems
Development of plant-wide control system
</td></tr>
<tr><td>Course Outcomes:</td><td>Upon completion of the course, students will be able to

Develop and analyse dynamic process models using state-space, transfer function, and empirical identification techniques.
Design and tune classical single-loop PID controllers and implement advanced control strategies such as cascade, feed-forward, and ratio control for complex processes.
Understand discrete-time control systems, including digital PID implementation, Z-transform methods, and real-time adaptive system identification.
Apply advanced process control techniques such as model predictive control (MPC) and nonlinear MPC for both single and multivariable systems.
Evaluate and design plant-wide control systems considering process interactions, degrees of freedom, and control structure impact on overall system performance.
</td></tr>
<tr><td>Course Contents:</td><td>UNIT I Control-relevant Process Modeling and Process Identification (10 Hrs)
Introduction, process model forms (state-space, transform-domain, frequency-response, impulse-response, transfer function models for continuous-time and discrete-time systems), formulating dynamic process models based on fundamental principles (theoretical modeling). Degrees of freedom and process control, linearization of non-linear process models. Process Identification (Empirical Process Modeling): Principles of empirical modeling, step, impulse, and frequency- response methods of identification.</td></tr>
</table>

	UNIT II Regulatory Control Systems (10 Hrs) Conventional (classical) single-loop feedback control systems: Servo and regulatory response characteristics, stability analysis methods, PID controller, PID controller design (tuning) methods. Enhancements to single-loop regulatory control (complex control structures): Design of Cascade control, feed forward control, ratio control, split-range control, override control, anti-reset windup. Controller design for processes with difficult dynamics: Controller design for time-delay systems, inverse-response systems, open-loop unstable systems. Multivariable Regulatory Control Systems, Introduction, multiple single-loop control systems, interaction analysis and loop pairing using relative gain array (RGA) method, decoupling control, singular value decomposition
	UNIT III Discrete-time Control Systems (Digital Computer Control Systems) (11 Hrs) Introduction, sampling and reconstruction of continuous-time signals (analog signals), Ztransform, discrete-time process models (ARMAX, ARX MA models), PRBS signal, empirical model identification using least-square estimation method, real-time identification, recursive adaptive algorithm for extended least-squares, dynamic analysis of discrete-time systems. Computer implementation of PID- controller, set-point weighted PID-controller, pole placement, digital controller design.
	UNIT IV Advanced Process Control Systems (APC) (11 Hrs) Model-based control systems (DS, GMC, IMC), single- and multivariable model-predictive control (MPC), non-linear MPC (NLMPC), batch process control systems.
	UNIT V Plant-wide Control Systems (10 Hrs) Introduction, interaction of plant design and control system design, hypothetical plant for plantwide control studies, systematic procedure for plant-wide control, degrees of freedom analysis, internal feedback of material and energy, steady-state and transient behavior flow-sheet controllability analysis, design of plant wide control systems, effect of control structure on closed-loop performance.
Reference Books:	1. Seborg, Edgar, Mellichamp, “Process Dynamics and Control”, Wiley student edition 2. Bequette, “Process Control”, Prentice Hall Publications

Semester II
PEC551CEE: PROGRAM SPECIFIC ELECTIVE COURSE

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
PEC551CEE	**4**	**50**	**50**	**--**	**--**	**100**	**4**

(Select any ONE)	
COURSE CODE	**TITLE**
PEC551ACEE	AI & Data Science in Chemical Engineering
PEC551BCEE	Advanced Wastewater Treatment and Emerging Technologies
PEC551CCEE	Chemical Safety and Risk Management
PEC551DCEE	Advanced Project Management Techniques

PEC551ACEE: AI & DATA SCIENCE IN CHEMICAL ENGINEERING	
Course Objectives:	• Understand AI basics and data-driven modeling in chemical engineering. • Learn key machine learning algorithms and their process applications. • Explore artificial neural networks and deep learning fundamentals. • Apply AI techniques for process control and optimization. • Examine recent AI advances and industrial use cases in chemical engineering.
Course Outcomes:	Upon completion of the course, students will be able to • Explain AI concepts and workflows relevant to chemical engineering. • Apply machine learning algorithms to solve chemical engineering problems. • Develop and evaluate ANN and deep learning models for process applications. • Use AI for process monitoring, control, and optimization. • Analyse recent AI technologies and case studies in industrial chemical processes.
Course Contents:	**UNIT I Introduction to Artificial Intelligence and Machine Learning (10 Hrs)** Introduction to AI: History, concepts, and relevance to Chemical Engineering, Types of learning: Supervised, unsupervised, reinforcement learning, Role of data-driven modeling in process systems, Basic statistical and probabilistic tools for AI, AI workflows: Data acquisition, preprocessing, feature selection, training, validation.
	UNIT II Machine Learning Techniques in Chemical Engineering (10 Hrs) Linear and logistic regression, support vector machines (SVM), Decision trees, random forests, k-nearest neighbors (k-NN), Ensemble methods: Bagging and boosting, Case studies in parameter estimation, fault detection, and process optimization, Application of ML in heat exchangers, reactors, and distillation

	columns.
	UNIT III Artificial Neural Networks and Deep Learning (10 Hrs) Basics of Artificial Neural Networks (ANN): structure, training, and backpropagation, Activation functions, loss functions, and optimization algorithms, Introduction to deep learning: CNNs, RNNs, LSTM, Hyperparameter tuning and model evaluation metrics, ANN applications in chemical reaction engineering, separation processes, and control.
	UNIT IV Process Control, Monitoring and Optimization with AI (11 Hrs) AI in process control: soft sensors, inferential modeling, Predictive maintenance using AI, Process optimization using AI and ML, Reinforcement learning in chemical process control, Applications in batch process optimization, fault detection, and control strategy development.
	UNIT V Recent Advances and Industrial Applications (11 Hrs) Digital twins in chemical plants, AI for sustainability: energy efficiency, emissions monitoring, Smart manufacturing, Industry 4.0 integration, Hybrid modeling: integration of first-principles and AI models, Case studies in pharma, petrochemicals, food, and water treatment industries
Reference Books:	1. **Venkatasubramanian, V.**, *Artificial Intelligence in Chemical Engineering*, Academic Press 2. **Montgomery, D.C.**, *Applied Statistics and Probability for Engineers*

PEC551BCEE: Advanced Wastewater Treatment and Emerging Technologies	
Course Objectives:	The objective of this course is to provide students with a comprehensive understanding and provide advanced knowledge of wastewater characterization and treatment. Develop expertise in the design and operation of advanced processes. Emphasize on research-based treatment strategies, especially on the Advanced Oxidation Processes (AOPs). Train students to evaluate cost-effectiveness, sustainability, and real-world applicability.
Course Outcomes:	Upon completion of the course, students will be able to • Critically evaluate complex wastewater matrices and advanced characterization methods. • Design and optimize advanced biological and physicochemical treatment processes. • Explain mechanisms and kinetics of Advanced Oxidation Processes (AOPs). • Compare and evaluate UV, Fenton, ozone-based, and hybrid AOPs in terms of

	efficiency and scalability. • Assess techno-economic and sustainability aspects of advanced wastewater treatment methods. • Propose innovative research-based solutions using emerging AOP technologies.
Course Contents:	**UNIT I Advanced Wastewater Characterization and Modeling (11 Hrs)** Sources and types of wastewaters, domestic, industrial, agricultural. Complex wastewater matrices: industrial and municipal. Water quality parameters (pH, BOD, COD, TDS, turbidity, DO). Advanced analytical techniques (spectroscopy, chromatography), Kinetics of pollutant degradation. Mathematical modeling of wastewater treatment processes.
	UNIT II Advanced Biological and Physicochemical Processes (10 Hrs) Biological nutrient removal (BNR) systems. Membrane bioreactors (MBR), moving bed biofilm reactors (MBBR). Membrane-based processes: ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO). Physicochemical processes: ion exchange, adsorption, advanced membranes. Industrial ecology and waste minimization.
	UNIT III Fundamentals of Advanced Oxidation Processes (AOP's) (11 Hrs) Principles and mechanisms of AOPs. Role of hydroxyl radicals in pollutant degradation. Reaction kinetics and scavenging effects. Applications for toxicity reduction and biodegradability enhancement.
	UNIT IV UV, Fenton, and Ozone-Based AOP's (10 Hrs) UV irradiation fundamentals, photolysis, and photocatalysis. Fenton and photo-Fenton processes (homogeneous and heterogeneous). Catalytic ozonation: fundamentals, kinetics, and applications. Synergistic effects of combined processes (UV/H_2O_2, O_3/UV).
	UNIT V Emerging and Hybrid AOP–Membrane Technologies (10 Hrs) Ultrasound and cavitation-based AOPs. Electrical discharge processes and water radiolysis. Hybrid AOP – membrane systems for wastewater polishing. Limitations, scale-up challenges, and future research directions.
Reference Books:	1. Advanced Oxidation Processes for Wastewater Treatment: Emerging Green Chemical Technology, Suresh C. Ameta, Rakshit Ameta, Academic Press Inc,. 2. Industrial Wastewater Treatment, Recycling, and Reuse, Vivek V. Ranade and Vinay M Bhandari, Butterworth–Heinemann

PEC551CCEE: CHEMICAL SAFETY AND RISK MANAGEMENT	
Course Objectives:	• To introduce chemical process safety, toxicology, industrial hygiene, and hazard identification tools. • To familiarize students with qualitative and quantitative risk assessment methods and consequence modelling. • To understand fire and explosion types, reactive hazards, and related modelling and mitigation. • To learn about inherently safer design, safety systems, relief devices, and loss prevention strategies. • To explore chemical safety laws, process safety management, and emergency response planning.
Course Outcomes:	• Understand fundamental principles of chemical process safety and evaluate historical industrial accidents. • Apply hazard identification and risk assessment techniques to chemical processes. • Analyze fire, explosion, and reactive hazards and propose suitable mitigation strategies. • Design and assess safety systems and loss prevention measures in chemical industries. • Interpret national and international regulatory frameworks and develop emergency response and safety management plans.
Course Contents:	**UNIT I Fundamentals of Chemical Process Safety (11 Hrs)** Introduction to chemical process safety and importance in industry, Historical incidents and lessons learned (Bhopal, Seveso, Flixborough, Texas City), Toxicology: routes of entry, dose-response curves, threshold limit values (TLV), lethal dose (LD50), Industrial hygiene: exposure assessment, personal protective equipment (PPE), control strategies, Hazard identification techniques: HAZID, checklists, safety audits
	UNIT II Hazard Analysis and Risk Assessment (11 Hrs) Quantitative Risk Assessment (QRA) and Qualitative methods, Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), Hazard and Operability Study (HAZOP) methodology and case examples, Consequence modeling: release rate, dispersion, fire, explosion modeling, Introduction to software tools (ALOHA, PHAST, SAFETI)

	UNIT III Fire, Explosion, and Reactive Hazards (10 Hrs) Fire triangle, types of fires (Class A, B, C, D, K), Flash point, autoignition temperature, flammability limits, Dust and vapor cloud explosions, BLEVE, jet fires, fireball modelling, Runaway reactions and reactive chemical hazards, Case studies of reactive incidents and explosion dynamics, Explosion-proof design, mitigation techniques
	UNIT IV Safety Systems and Loss Prevention (10 Hrs) Inherently Safer Design (ISD) principles: minimization, substitution, moderation, simplification, Layers of protection: alarms, relief systems, interlocks, emergency shutdown systems, Pressure relief devices: safety valves, rupture disks, flare systems, Fire and gas detection systems, sprinkler systems, Passive and active mitigation strategies, Maintenance, inspection, and reliability of safety systems
	UNIT V Regulatory Framework, Standards and Emergency Management (10 Hrs) OSHA, EPA, NFPA, REACH, ISO 45001, ISO 14001, Chemical safety regulations in India: Factories Act, MSIHC Rules, BIS Standards, Process Safety Management (PSM) systems and elements, Emergency preparedness and disaster management planning, Incident investigation and root cause analysis, Risk communication, safety culture, and behavior-based safety (BBS)
Reference Books:	**1.** Crowl, D.A. & Louvar, J.F., Chemical Process Safety: Fundamentals with Applications, Prentice Hall **2.** Mannan, S., Lees' Loss Prevention in the Process Industries, Butterworth-Heinemann

PEC552DCEE: ADVANCED PROJECT MANAGEMENT TECHNIQUES	
Course Objectives:	To understand the principles and practices of advanced project management. To introduce project planning, scheduling, risk management, and cost control techniques. To apply modern project management tools like CPM, PERT, and software-based scheduling. To integrate safety, sustainability, and quality into chemical engineering projects.

Course Outcomes:	• Analyze complex engineering projects using advanced project management tools and techniques. • Develop comprehensive project plans addressing cost, time, resources, and risk. • Apply quantitative and software tools like PERT/CPM and MS Project/Primavera in project execution. • Evaluate project performance based on earned value management and KPIs. • Integrate sustainability, safety, and quality management into project lifecycle.
Course Contents:	**UNIT I Introduction to Project Management (06 Hrs)** Introduction to Project Management, Project lifecycle, Project manager roles, Success criteria, Types of engineering projects
	UNIT II Project Planning and Scheduling (12 Hrs) Project Planning and Scheduling Work breakdown structure (WBS), Gantt charts, Network diagrams, Resource allocation, CPM and PERT methods.
	UNIT III Risk and Cost Management (10 Hrs) Risk and Cost Management Project budgeting and estimation, Risk identification and mitigation, Cost control, Sensitivity analysis, Contingency planning.
	UNIT IV Project Monitoring and Control (10 Hrs) Progress tracking, Earned value analysis, Performance metrics (SPI, CPI), Change management, Project closure.
	UNIT V Advanced Tools and Case Studies (14 Hrs) Use of software tools (MS Project, Primavera), Multi-project environments, Case studies in Chemical plant design, Safety and Sustainability aspects.
Reference Books:	**1.** Kerzner H., Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Wiley, 12th ed., 2017. **2.** PMI, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 7th Edition, Project Management Institute, 2021.

LC532CEE: Chemical Lab – II

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr. Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
LC532CEE	4	--	--	25	25	50	2

Course Objectives:	• To develop skills in food product development, sensory analysis, and quality control methodologies. • To explore strain improvement strategies through genetic and metabolic engineering. • To apply fermentation technology in industrial production and waste valorisation with an emphasis on biosafety and regulations. • To equip students with hazard identification, qualitative and quantitative risk assessment tools. • To impart knowledge of smart and functional materials and their relevance to chemical engineering applications.
Course Outcomes:	After successful completion of the course, learner will be able to **CO1:** Analyze and simulate food preservation processes including thermal and non-thermal techniques. **CO2:** Model microbial growth and substrate/product kinetics for different fermentation types. **CO3:** Design and simulate various bioreactor systems considering scale-up, aeration, and agitation. **CO4:** Evaluate chemical process safety incidents using toxicological and industrial hygiene principles. **CO5**: Simulate and interpret nanomaterial behavior and thin film characteristics for industrial use.
Course Contents:	**Important instructions:** The students are required to preserve the samples, compounded materials, test specimens, tested specimens, 'original' result papers such as charts, graphs, data sheets soft copies of modelling and analysis etc. and should be submitted along with the journal for evaluation failing which the TW will not be granted. The laboratory work will be based on completion of assignments confined to the courses of that semester. The assessment will be done jointly by the pair of internal and external examiners along with the oral examination of the same. Each student should perform **at least 08 experiments from the following list** and submit the journal which will form the term-work for the subject.

	Important Note: • **Each experiment is to be supported with compulsory assignment which should be the part of the journal.** • **Study experiments are strictly avoided as Chemical Lab – II experiment.** **List of experiments** • Model microbial death rate under thermal treatment; determine D-value and z-value for pasteurization. • Use Fick's second law to simulate drying curves for fruits or vegetables and estimate drying rate constants. • Predict shelf life of packaged food under different temperatures by modeling chemical or microbial spoilage rates. • Simulate ultrafiltration or nanofiltration for juice purification; analyze flux, rejection, and fouling • Apply Monod kinetics and simulate biomass and product growth in batch fermentation. • Model Michaelis-Menten kinetics and simulate enzyme activity before and after immobilization. • Analyze flow curves and model viscosity data of non-Newtonian food materials like ketchup or yogurt. • Perform principal component analysis (PCA) or cluster analysis on sensory panel data for multiple food samples. • Simulate batch growth using Monod, Andrews, or logistic growth models; plot biomass, substrate, and product over time. • Model substrate addition and product formation in fed-batch fermentation; perform stability analysis and productivity calculation. • Calculate volumetric oxygen transfer coefficient (kLa) using dynamic gassing-out method; simulate effects of agitation and aeration. • Optimize media components (C:N ratio, minerals) to maximize product yield using statistical models and contour plots. • Model foam generation kinetics and evaluate the effectiveness of antifoam agents using PID control schemes. • Design and simulate cell separation and product recovery steps including material balance, pressure drop, and drying kinetics.

	• Perform stoichiometric modeling of E. coli or yeast metabolism for ethanol or antibiotic production; identify bottlenecks. • Model mass and energy balances in ethanol production via fermentation route; simulate purification stages like distillation. • Generate and analyze dose-response plots; determine LD50, TLV, and NOAEL from given toxicological data. • Construct FTA and ETA models for a reactor system; calculate probability of top events and evaluate mitigation paths. • Perform QRA on a chemical plant scenario; estimate risk index based on frequency and severity. • Simulate overpressure from BLEVE or vapor cloud explosion; determine impact radius and blast damage. • Simulate relief system sizing for a high-pressure vessel; evaluate flare stack operation under relief conditions. • Use Gaussian plume models to simulate toxic release dispersion in open air and assess affected zones. • Model temperature and pressure changes during an exothermic runaway reaction; identify conditions for thermal stability. • Conduct a full HAZOP for a simulated distillation or reactor system; identify deviations, causes, and Safeguards. • Model simple cubic, BCC, and FCC structures; simulate point defects and dislocation effects on mechanical strength. • Plot and interpret binary phase diagrams; correlate phase transformation with changes in hardness, ductility, etc. • Simulate molecular weight distribution and model viscoelastic behavior using Maxwell or Voigt models. • Calculate modulus, density, and strength of composite materials using theoretical and empirical models. • Simulate quantum confinement and its effect on optical absorption for nanomaterials. • Model film thickness vs time for chemical and physical vapor deposition under different operating conditions. • Simulate anodic/cathodic reactions and calculate corrosion current density using Tafel equations.

	• Use weighted property matrix for selecting materials for high-temperature reactors, membranes, etc., based on given case studies. • **Any other simulation experiment/s in consultation with teaching faculty**

Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus. It is to be submitted as term work at the end of semester after continuous assessment of each by respective teacher.

Semester II

AEC561DES: Research Methodology and IPR

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
AEC561DES	4	50	50	--	--	100	4

Course Objectives:	• Understand the fundamentals of research methodology, formulation of research problems, and design of experiments. • Develop the ability to conduct literature reviews, use research tools, and interpret data. • Understand ethical issues in research, technical writing, and publishing. • Familiarize students with Intellectual Property Rights and patent laws. • Understand the process of patenting, IP commercialization, and protection of innovations.
Course Outcomes:	Upon completion of the course, students will be able to • Understand research fundamentals, problem formulation, and research process • Design research studies and apply appropriate data collection and analysis methods • Develop skills in scientific writing, referencing, and ethical research conduct • Comprehend various types of IPR and their significance in innovation protection • Demonstrate knowledge of patent filing, IP commercialization, and legal considerations
Course Contents:	**UNIT I Introduction to Research Methodology (10 Hrs)** Meaning and objectives of research, Types of research: basic, applied, qualitative, quantitative, empirical, exploratory, Research process and flowchart, Research problem formulation and hypothesis development, Characteristics of good research Defining research objectives and scope
	UNIT II Research Design and Data Collection (10 Hrs) Types of research design: experimental, descriptive, exploratory, Sampling techniques and sample size determination, Methods of data collection: primary and secondary data, surveys, interviews, case studies, Measurement scales, validity, and reliability, Overview of statistical tools (mean, SD, correlation, regression)

	UNIT III Technical Writing and Research Ethics (10 Hrs) Structure and components of research reports, thesis, and papers, writing style: clarity, precision, citations, referencing (APA/IEEE), Plagiarism, paraphrasing, and tools for plagiarism detection, Ethical issues in research: data fabrication, falsification, conflict of interest, Peer review process and publication ethics
	UNIT IV Introduction to IPR and Patent System (11 Hrs) Introduction to Intellectual Property Rights (IPR): types and importance, Patents, copyrights, trademarks, industrial designs, trade secrets, Indian and global patent systems: WIPO, TRIPS, WTO, Patentability criteria: novelty, inventive step, industrial application, Non-patentable inventions in India
	UNIT V Patent Filing and IPR Management (11 Hrs) Patent search and drafting basics (claims, specifications), Patent filing procedure (India and PCT routes), Infringement and litigation, Technology transfer, licensing, and commercialization, Role of IPR in academia and industry, Case studies on patents and technology innovation
Text Book:	• C.R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2004 • **Ranjit Kumar**, *Research Methodology: A Step-by-Step Guide for Beginners*, Sage Publications, 4th Edition • Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications, 4th Edition
Reference Books:	• **Wayne Goddard & Stuart Melville**, *Research Methodology: An Introduction* • Yogesh Kumar Singh, *Fundamental of Research Methodology and Statistics*, New Age • **Prabuddha Ganguli**, *Intellectual Property Rights: Unleashing the Knowledge Economy*, Tata McGraw Hill • WIPO – *Intellectual Property Handbook* (Free PDF from wipo.int) • Recent UGC / AICTE guidelines on plagiarism and academic integrity

Semester II

OE: OPEN ELECTIVE

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
OE	4	50	50	--	--	100	4

(Select any ONE)	
COURSE CODE	**TITLE**
OE573CON	Organizational Ethics and Human Resource Management
OE571CEE	Economics of Innovation
OE573STR	Financial Management
OE571PED	Entrepreneurship Development

OE573CON: ORGANIZATIONAL ETHICS AND HUMAN RESOURCE MANAGEMENT	
Course Objectives:	• To introduce fundamental concepts of Human Resource Management. • To introduce the processes pertaining to different functions of HRM. • To introduce the recent trends with respect to global HRM.
Course Outcomes:	Upon completion of the course, students will be able to: • Explain concepts and leadership approaches in organizational ethics. • Apply governance and stakeholder principles for ethical practices. • Describe functions and roles of Human Resource Management. • Implement manpower planning, recruitment, and selection methods. • Evaluate training, development, and performance appraisal systems.
Course Contents:	**UNIT I ORGANIZATIONAL ETHICS (10 Hrs)** Introduction to Organizational Ethics: Definition, scope, and significance in engineering and technology-driven organizations; distinction between legal compliance and ethical responsibility. Ethical Theories and Frameworks: Overview of utilitarianism, deontology, virtue ethics; application of ethical principles to engineering decision-making and dilemmas. Ethical Leadership: Role of leadership in shaping ethical behavior; ethical decision-making by managers; ethical influence and personal integrity in leadership.

	UNIT II Governance, Culture, and Stakeholder Ethics (10 Hrs) Corporate Governance: Principles of transparency, accountability, and ethical oversight; governance structures in engineering organizations. Ethical Culture and Infrastructure: Organizational culture, codes of conduct, ethics committees, whistleblowing mechanisms, and compliance frameworks. Stakeholder Ethics and CSR: Stakeholder theory; corporate social responsibility (CSR); ethical challenges in supply chains, sustainability, and technological innovation.
	UNIT III Introduction to Human Resource Management (10 Hrs) Introduction, Development of HRM, Concept of Human Resource Development (HRD)& HRM, Importance of Human Resource Management., Functions of Human Resource Management., Role of HR Manager, Structure of HRM Department, Duties and Responsibilities of HR-Manager.
	UNIT IV Manpower Planning And Recruitment And Selection (11 Hrs) Definition and objectives, Need, Importance of Human Resource Planning: Short term and Long term, Process of Human Resource Planning, Concept of Recruitment, Importance of Recruitment, Sources of Recruitment, Concept of Selection, Importance of selection, Selection Tests and Types of Interviews, Facing Interviews, Basis of Selection, Induction
	UNIT V Training And Development And Performance Appraisal (11 Hrs) Definition of Training and Development, Methods & Types of Training, Objectives and Importance of Training, Training Methods, Evaluation of Training Programme, Models of Evaluation, Cross-Cultural Training, Concept of Management Development, Concept of Performance Appraisal, Importance of Performance Appraisal, Methods of Performance Appraisal, Errors of Appraisal. Merit Rating: Need, and Methods, Job Evaluation, Job Description, Movement of human resources within organization (Promotion, Transfer, Job Enlargement, Job Enrichment, Job rotation, Job Sharing.)

Reference Books:	- Mike W. Martin & Roland Schinzinger, *Ethics in Engineering*, McGraw-Hill Education - Charles D. Fleddermann, *Engineering Ethics*, Pearson Education - Laura P. Hartman & Joe DesJardins, *Business Ethics: Decision Making for Personal Integrity and Social Responsibility*, McGraw-Hill Education - Gary Dessler, *Human Resource Management*, Pearson Education - V.S.P. Rao, *Human Resource Management: Text and Cases*, Excel Books K. Aswathappa, *Human Resource Management*, McGraw-Hill Education - Michael Armstrong, *A Handbook of Human Resource Management Practice*, Kogan Page

OE571CEE: ECONOMICS OF INNOVATION	
Course Objectives:	- To understand the role of innovation in economic growth and industrial competitiveness. - To explore the economics behind R&D investment, knowledge spillovers, and intellectual property. - To analyze innovation systems, market structures, and technology policy. - To equip students with economic tools to evaluate innovation strategies in firms and nations. - To understand the relationship between innovation, entrepreneurship, and sustainability.
Course Outcomes:	Upon completion of the course, students will be able to: - Explain key concepts, theories, and historical evolution of innovation in economic growth. - Analyze the economics of R&D, market structure, and firm-level innovation strategies. - Evaluate knowledge spillovers, innovation networks, and the role of IPRs in innovation. - Assess national innovation systems, policies, and international innovation comparisons. - Examine the relationship between innovation, entrepreneurship, and emerging global challenges.
Course Contents:	**UNIT I Introduction to Innovation and Economic Growth (10 Hrs)** Definitions: Innovation, invention, diffusion, and R&D, Schumpeterian theory of innovation and creative destruction, Innovation and productivity growth, Linear and non-linear models of innovation, Historical evolution of industrial innovation (1st to 5th industrial revolution)

	UNIT II Economics of R&D and Firm-Level Innovation (10 Hrs) R&D as an investment: uncertainty, risk, and returns, Firm size, market structure, and innovation behavior, Patents, licensing, and appropriability of innovation, Internal vs external sources of innovation (open innovation), Innovation in SMEs and startups
	UNIT III Knowledge Spillovers, Networks, and IPRs (10 Hrs) Knowledge as a public good and externalities, Spillovers and clustering (Silicon Valley, innovation hubs), IPRs: patents, copyrights, trade secrets – economic rationale and impact, Innovation networks and collaboration: universities, labs, firms, Limitations of strong IPR regimes – TRIPS, patent races
	UNIT IV National Innovation Systems and Policy Instruments (11 Hrs) National and regional innovation systems (NIS/RIS),Role of government: subsidies, tax incentives, regulation, Innovation policy tools: mission-oriented R&D, public procurement, standards, International comparison: US, EU, India, China, Japan, Evaluation of public R&D programs and innovation outcomes
	UNIT V Innovation, Entrepreneurship, and Emerging Issues (11 Hrs) Innovation and entrepreneurship: Schumpeter vs Kirzner, Disruptive innovation and business model innovation, Innovation and sustainable development (green innovation, social innovation), Digital economy, platform innovation, and Industry 4.0, Inclusive innovation, frugal innovation, and innovation in developing countries
Reference Books:	1. Fagerberg, Jan, Mowery, David C., and Nelson, Richard R. *The Oxford Handbook of Innovation* – Oxford University Press 2. Schumpeter, Joseph A.*Capitalism, Socialism and Democracy* – Harper 3. Martin, Ben R. *Research and Innovation: Concepts, Theories and Perspectives* – Edward Elgar Publishing 4. Nathan Rosenberg *Inside the Black Box: Technology and Economics* – Cambridge University Press 5. Hall, Bronwyn H., and Rosenberg, Nathan (Eds.) *Handbook of the Economics of Innovation* – Elsevier 6. Freeman, Christopher *Technology Policy and Economic Performance: Lessons from Japan* – Pinter Publishers 7. OECD Reports – *Science, Technology and Innovation Outlook* (Latest Editions), www.oecd.org/sti 8. World Intellectual Property Organization (WIPO) – *Global Innovation Index Report*

<table>
<tr><th colspan="2">OE573STR: FINANCIAL MANAGMENT</th></tr>
<tr><td>Course Objectives:</td><td>By the end of this course, students will be able to
Understand the principles of financial management and their relevance to engineering projects.
Learn financial planning, budgeting, and risk analysis methods tailored to engineering projects.
Gain knowledge of project financing options, working capital management, and cash flow forecasting.
Apply cost control techniques and financial appraisal tools in Engineering projects.
Analyze financial performance, make informed decisions under uncertainty, and evaluate real-world case studies.</td></tr>
<tr><td>Course Outcomes:</td><td>Upon completion of the course, students will be able to:
Interpret financial statements and apply ratio analysis and time value of money concepts.
Prepare project budgets and evaluate investments using capital budgeting techniques.
Analyze project financing options, capital structure, and working capital requirements.
Apply cost control methods and assess emerging financial technologies in industry.
Evaluate financial performance and make informed investment decisions using real-world case studies.</td></tr>
<tr><td rowspan="2">Course Contents:</td><td>Unit 1: [11 hours]
Introduction to Financial Management: Scope and objectives of financial management, Functions and role of financial manager in engineering organisations, Financial statements: balance sheet, income statement, cash flow statement. Ratio analysis: liquidity, profitability, solvency, and efficiency ratios. Time value of money: Present value, future value, annuity.</td></tr>
<tr><td>Unit 2: [10 hours]
Financial Planning and Budgeting for Projects: Project cost estimation and budgeting methods, Preparation of detailed project reports (DPR), Risk analysis in financial planning, Capital budgeting: Payback period, NPV, IRR, benefit-cost ratio, Engineering project investment evaluation examples.</td></tr>
</table>

	Unit 3: **[10 hours]** Project Financing and Working Capital Management: Capital structure: concepts, theories, and practical considerations. Long-term and short-term sources of finance, Sources of finance: Equity, debt, bonds, leasing, Public-Private Partnerships (PPP), Venture capital, start-up funding, and project financing in technology sectors. Working capital: Meaning, need, determinants, cash flow forecasting and fund flow analysis.
	Unit 4: [11 hours] Cost Control and Financial Appraisal: Cost control techniques: Earned Value Management (EVM), S-curve, Break-even analysis and profitability analysis. Internal financial audits and reporting. Accounting systems and cost codes. Introduction to fintech, blockchain, and digital payment systems in industry
	Unit5: **[10 hours]** Financial Decision-Making and Case Studies: Investment analysis for infrastructure and structural projects. Financial performance indicators: ROI, ROE, profitability ratios. Decision-making under uncertainty. Case studies: Financial failures and success in major projects, Real-world examples of financial decision making in engineering firms.
Reference Books:	• Prasanna Chandra, Financial Management: Theory and Practice, McGraw-Hill • Leland Blank & Anthony Tarquin, Engineering Economy, McGraw-Hill • Harold Kerzner, Project Management: A Systems Approach, Wiley • I.M. Pandey, Financial Management, Vikas Publishing • Bhabatosh Banerjee, Fundamentals of Financial Management, PHI • M.Y. Khan & P.K. Jain, Financial Management, Tata McGraw-Hill

OE571PED: ENTREPRENEURSHIP DEVELOPMENT	
Course Objectives:	• To develop an entrepreneurial mindset among postgraduate engineering students. • To equip students with knowledge of business planning, funding, and venture creation. • To familiarize students with innovation, IPR, and start-up ecosystem relevant to technology ventures. • To prepare students for launching and managing sustainable enterprises.

Course Outcomes	Upon completion of the course, students will be able to • Explain the fundamentals of entrepreneurship and the entrepreneurial ecosystem. • Identify and evaluate potential business opportunities. • Prepare business plans and manage projects effectively. • Select appropriate funding sources and manage start-up finances. • Implement growth strategies and adapt to emerging trends in entrepreneurship.
Course Contents:	**Unit I: Introduction to Entrepreneurship (10 Hours)** • Concept and definition of entrepreneurship • Types of entrepreneurs: technopreneurs, social entrepreneurs, intrapreneurs • Characteristics of successful entrepreneurs • Role of entrepreneurship in economic development • Barriers to entrepreneurship and strategies to overcome them • Entrepreneurial ecosystem in India – national and state-level initiatives
	Unit II: Entrepreneurial Motivation and Opportunity Identification (10 Hours) • Creativity, innovation, and idea generation techniques • Opportunity identification and evaluation • Market research for business ideas • Feasibility analysis: technical, financial, and market feasibility • Case studies of technology-based start-ups
	Unit III: Business Planning and Project Management (10 Hours) • Components of a business plan • Preparing business models using tools like Business Model Canvas (BMC) • Basics of project planning and scheduling (PERT, CPM) • Risk assessment and mitigation in start-up ventures • Cost estimation and break-even analysis for start-ups
	Unit IV: Funding and Financial Management for Entrepreneurs (12 Hours) • Sources of finance: self-financing, angel investors, venture capital, bank loans, government schemes • Crowd funding and alternative financing • Basics of financial statements for entrepreneurs • Working capital management in start-ups • Pricing strategies for products and services

	Unit V: Scaling, Sustainability, and Emerging Trends in Entrepreneurship **(10 Hours)** • Scaling up: growth strategies for start-ups • Social and green entrepreneurship • Entrepreneurship for Industry 4.0 and emerging technologies • Role of incubators, accelerators, and innovation hubs • Contemporary trends: digital entrepreneurship, gig economy, and platform-based business models
Reference Books:	• S.S. Khanka, *Entrepreneurial Development*, S. Chand Publishing. • Vasant Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House. • Hisrich, R.D., Peters, M.P., and Shepherd, D.A., Entrepreneurship, McGraw-Hill Education. • Donald F. Kuratko, Entrepreneurship: Theory, Process, and Practice, Cengage Learning. • Peter F. Drucker, Innovation and Entrepreneurship, Harper Business. • Rajeev Roy, Entrepreneurship, Oxford University Press. • David H. Holt, Entrepreneurship: New Venture Creation, Prentice Hall of India. • Poornima M. Charantimath, Entrepreneurship Development and Small Business Enterprises, Pearson Education.

Semester II

MLC542DES: Sustainable Engineering and Circular Economy

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>MLC542DES (Non-credit)</td><td>2</td><td>50</td><td>50</td><td>--</td><td>--</td><td>100</td><td>--</td></tr>
</table>

Course Objectives:	• Understand the relevance and the concept of sustainability and the global initiatives • Explain the different types of environmental pollution problems and their sustainable Solutions • Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles • Contrive skilled manpower and entrepreneurship in the field of Circular Economy • Enhance interaction of students with the senior/experienced manpower who have real time knowledge / experience in the technology development, research, innovation, entrepreneurship deployment and circular business models
Course Outcomes:	Upon completion of the course, students will be able to • Understand the relevance and the concept of sustainability and the global initiatives in this Direction • Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles • Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles • Use the principles of circularity for application to sustainable development • Apply complexity aspects of circular economy for creating circular business models
Course Contents:	**UNIT I** **(10 Hrs)** Sustainability- need and concept, technology and sustainable Development-Natural resources and their pollution, Carbon credits, Zero waste concept. Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable urbanization,

	concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.
	UNIT II **(10 Hrs)** Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM). Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R, Circular economy, Bio-mimicking, Environment Impact Assessment (EIA)
	UNIT III **(10 Hrs)** Resources and its utilization: General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy. Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in thermal utilities and electrical utilities.
	UNIT IV **(11 Hrs)** Linear Economy and its emergence, Economic and Ecological disadvantages of linear economy, Replacing Linear economy by Circular Economy, Development of Concept of Circular Economy, A differential - Linear Vs Circular Economy Material recovery, Waste Reduction, reducing negative externalities, Explaining Butterfly diagram, Concept of Loops
	UNIT V **(11 Hrs)** Solid Waste Management / Wastewater, Plastics: A case study, EPR: polluters pay principle, Industrial symbiosis/ Eco-parks Role of governments and networks, Sharing best practices, Universal circular economy policy goals, India and CE strategy, ESG, Zero waste: Waste Management in context of Circular Economy, Circular design, Circular Business Models
Reference Books:	• Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall. • Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning • Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios Publication

	• The Circular Economy Handbook: Realizing The Circular Advantage , Peter Lacy, Jessica Long, , Wesley Spindler , Palgrave Macmillan UK • Towards Zero Waste: Circular Economy Boost, Waste to Resources María-Laura Franco-García, Jorge Carlos Carpio-Aguilar, Hans Bressers. Springer International Publishing 2019 • Circular Economy: Global Perspective Sadhan Kumar Ghosh, Springer, 2020 • The Circular Economy A User's Guide, Walter R Stahel , Routledge; 1st Edition (24 June 2019) • Circular Economy: (Re) Emerging Movement , Shalini Goyal Bhalla , Invincible Publisher

Course Syllabus

Semester - III

Semester III

VSE611CEE: Dissertation Phase-I

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
VSE611CEE	12	--	--	100	50	150	6

DISSERTATION WORK:

The dissertation work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

Dissertation Phase – I

Dissertation Phase – I is the integral part of the project Work. In this, the student shall complete the partial work of the Project that will consist of problem statement, literature review, project overview, scheme of implementation (UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. The candidate shall deliver a presentation as a part of the progress report of Project work Stage-I, on the selected dissertation topic.

The student shall submit the progress report of Project Work Stage-I in standard format duly certified for satisfactory completion of the work by the concerned guide. The report must undergo plagiarism screening using anti-plagiarism software, and the similarity index shall not exceed 25%.

Semester III

SLC621CEE: Massive Open Online Course -I

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>SLC621CEE</td><td>4</td><td>--</td><td>--</td><td>100</td><td>--</td><td>100</td><td>4</td></tr>
</table>

Students shall select a MOOC course related to current trends in their respective engineering discipline, preferably aligned with their area of specialization. The course must be at the postgraduate level and should be selected in consultation with the assigned guide and approved by the designated authority. It may be taken from recognized MOOC platform such as NPTEL. Students are required to submit hard copies of all course assignments. The student is expected to register for the examination and obtain the certificate from competent authority.

Evaluation Guidelines: Students will be evaluated progressively for a total 100 Marks.

Sr. No.	Parameter	Marks
1	Presentation of the Selected topic	20
2	Assignment Scores	50 (The total marks obtained in the assignments shall be proportionally converted to an equivalent score out of 50.)
3	Certification Granted Based on the MOOC Provider's Examination	30
Total Marks		**100**

Semester III

VSE612CEE: Internship/On Job Training

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
VSE612CEE	16	--	--	100	100	200	8

INTERNSHIP/ ON JOB TRAINING:

Each student shall undertake an internship/ On job training of **8–10 weeks** in an industry, research institute, or consultancy firm under the guidance of an allocated faculty supervisor. The faculty guide shall be responsible for monitoring and evaluating the student's progress, in coordination with the industry/research supervisor.

Students must maintain a detailed project diary recording tasks performed, data collected, observations made, and challenges encountered. Progress shall be demonstrated through regular reporting, presentations, and proper documentation. The student is required to meet with the institute supervisor fortnightly to discuss and record progress.

Three progress reviews will be conducted during the internship:

Review–I: Understanding of the organization, assigned tasks, and work plan. (20 Marks)

Review–II: Mid-term progress, skill application, and problem-solving approach. (20 Marks)

Review–III: Completion status, demonstration of outcomes, and final feedback. (20 Marks)

The documentation comprising training report, project diary will carry 40 Marks.

Upon completion, the student shall submit a comprehensive internship report summarizing skills acquired, activities undertaken, challenges faced, and results achieved. A completion certificate from the host organization is mandatory. The final evaluation will be based on the internship report, feedback from the industry/research guide, and an oral examination.

Semester III

MLC643AID: HUMAN RIGHTS

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
MLC643AID	2	50	--	--	--	50	2

Course Objectives:	• Understand the concept, evolution, and values underpinning human rights. • Learn constitutional provisions and state mechanisms for human rights in India. • Recognize human rights issues in social, industrial, and engineering contexts. • Appreciate the role of citizens, NGOs, and civil society in protecting rights. • Gain awareness of international human rights instruments and systems.
Course Outcomes:	On completion, students will be able to: • Explain the foundations and values of human rights. • Interpret constitutional safeguards for human rights in India. • Evaluate the role of state institutions in rights protection. • Analyze human rights challenges in industrial and environmental contexts. • Assess the role of citizens and NGOs in human rights advocacy. • Compare national and international human rights frameworks.
Course Contents:	**UNIT I Human Rights – Concept, Development, Evolution (6 Hrs)** Basic Concept: a) Human Values- Dignity, Liberty, Equality, Justice, Unity in Diversity, Ethics and Morals, b) Meaning and significance of Human Rights; Education Philosophical, sociological and political debates, benchmarks of human rights movement.
	UNIT II Human Rights and the Indian Constitution (6 Hrs) Constitutional framework, Fundamental Rights & Duties, Directive Principles of State Policy, Welfare State & Welfare Schemes
	UNIT III Human Rights & State Mechanisms (6 Hrs) Police & Human Rights, Judiciary & Human Rights, Prisons & Human Rights, National and State Human Rights Commissions
	UNIT IV Human Rights of the Different Sections and contemporary issues (6 Hrs)

	Unorganized Sector, Right to Environment, particularly Industrial sectors of Chemical and Environmental Engineering, Globalization and Human Rights, Right to Development **Citizens' Role and Civil Society** Social Movements and Non-Governmental Organizations, Public Interest Litigation, Role of Non-Government organizations in implementation of Human rights. - Right to Information
	UNIT V Human Rights and the international scene (6 Hrs) Primary Information with reference to Engineering Industry, UN Documents, International Mechanisms (UN & Regional), International Criminal Court, Fundamental Rights & Duties, Directive Principles of State Policy, Welfare State & Welfare Schemes
Reference Books:	• Introduction to International Humanitarian Law by Curtis F. J. Doebbler - CD Publishing • Human Rights in India: A Mapping, Usha Ramanathan: free download from http://www.ielrc.org/content/w0103.pdf • Study material on UNESCO, UNICEF web site • Information, by Toby Mendel - UNESCO, 2008

Semester III

MLC602DES: Introduction to Constitution

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>MLC601DES</td><td>2</td><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td><td>2</td></tr>
</table>

<table>
<tr><td>Course Objectives:</td><td>This course introduces students to the Constitution of lndia. The Constitution, being supreme law of the land, must be known to every citizen of India. It begins with the Preamble, which indicates the source and objects of it. We, the people of India, are the source of the Constitution and have resolved to constitute India into a sovereign, socialist, secular, democratic and republic. The Course has been designed for everyone to make acquaint themselves with their fundamental rights and of others. No right is absolute one; it is subject to others right, as well. Directive Principles of State Policy are nothing but rights, though not enforceable by any court. These Directive Principles are basically ' Fundamental Principles' in the governance of the country. Powers and freedoms come with responsibility, State's responsibility to implement Directive Principles and citizens must perform their duties towards others, society and nation.</td></tr>
<tr><td>Course Outcomes:</td><td>To introduce the philosophy of Constitution of India to students.
To acquaint them with their freedoms and responsibilities.</td></tr>
<tr><td rowspan="2">Course Contents:</td><td>UNIT I: PHILOSOPHY OF THE INDIAN CONSTITUTION (07 Hrs)
a) Constitutional History of India b) Role of Dr. B.R. Ambedkar in Constituent Assembly c) Preamble - Source and Objects d) Sovereign and Republic e) Socialist and Secular f) Democratic - Social and Economic Democracy g) Justice - Social, Economic and Political h) Liberty - Thought, Expression, Belief, Faith and 'vVorship i) Equality - Status and Opportunity j) Fraternity, Human Dignity, Unity and Integrity of the Nation</td></tr>
<tr><td>UNIT 2: FUNDAMENTAL RIGHTS (07 Hrs)
.a) Right to equality b) Right to freedoms c) Right against exploitation d) Right to freedom of religion e) Cultural and educational rights f) Right to property g) Right to constitutional remedies</td></tr>
</table>

	UNIT 3: DIRECTIVE PRINCIPLES OF STATE POLICY (08 Hrs) a) Equal Justice and free legal aid b) Right to work and provisions for just and humane conditions of work c) Provision for early childhood, Right to education and SC,ST, weaker section d) Unifonn Civil Code e) Standard of Living, nutrition and public health f) Protection and improvement of environment g) Separation of Judiciary from executive h) Promotion of International peace and security.
	UNIT 4: FUNDAMENTAL DUTIES (08 Hrs) a) Duty to abide by the Constitution b) Duty to cherish and follow the noble ideals c) Duty· to defend the country and render national service d) Duty to value and preserve the rich heritage of our composite culture e) Duty to develop scientific temper, humanism, the spirit of inquiry & reform f) Duty to safeguard public prope1ty and abjure violence g) Duty to strive towards excellence.
Reference Books:	• D. D. Basu, Introduction to the Constitution of India, LexisNexis • Granville Austin, The Constitution of India: Cornerstone of a Nation, Oxford University Press • Subhash Kashyap, Our Constitution, National Book Trust • M.P. Jain, Indian Constitutional Law, LexisNexis • V.N. Slmkla, Constitution of India, Eastern Book Company • P.M. Bakshi, The Constitution of India, Universal Law Publishing • M.V. Pylee, Constitutional Government in India, S. Chand • V. S. Khare, Dr. B.R. Ambedkar and India's National Security

Course Syllabus

Semester - IV

Semester IV

VSE613CEE: Dissertation Phase – II

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr.Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
VSE613CEE	**24**	**--**	**--**	**200**	**100**	**300**	**12**

In Dissertation Phase – II, the student shall complete the balance part of the Project that will consist of fabrication of set up required for the project, conducting experiments and taking results, analysis & validation of results and conclusions.

The student shall prepare the final report of Project work in standard format duly certified for satisfactory completion of the work by the concerned guide. The dissertation must undergo plagiarism screening using anti-plagiarism software, and the similarity index shall not exceed 25%. It is mandatory to publish **one paper in conference** and **one paper in peer reviewed journal** before submission of the dissertation.

Semester IV

SLC622CEE: Massive Open Online Course -II

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Lect/Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCA</th><th>ESE</th></tr>
<tr><td>SLC622CEE</td><td>4</td><td>--</td><td>--</td><td>100</td><td>--</td><td>100</td><td>4</td></tr>
</table>

Students shall select a MOOC course related to current trends in their respective engineering discipline, preferably aligned with their area of specialization. The course must be at the postgraduate level and should be selected in consultation with the assigned guide and approved by the designated authority. It may be taken from recognized MOOC platform such as NPTEL. Students are required to submit hard copies of all course assignments. The student is expected to register for the examination and obtain the certificate from competent authority.

Evaluation Guidelines: Students will be evaluated progressively for a total 100 Marks.

Sr. No.	Parameter	Marks
1	Presentation of the Selected topic	20
2	Assignment Scores	50 (The total marks obtained in the assignments shall be proportionally converted to an equivalent score out of 50.)
3	Certification Granted Based on the MOOC Provider's Examination	30
Total Marks		**100**

Semester IV

CCA631CEE: Co-curricular & Extracurricular Activities

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Pr.Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
CCA631CEE	4	--	--	25	25	50	2

Students are expected to OPT one out of the following:

- Seminar on any advanced topic selected from program specific elective.

  Guidelines:
  - Topic Selection: Choose a recent/advanced topic from the elective list, approved by guide; no duplication allowed.
  - Report: 8–12 pages, Times New Roman 12pt, 1.5 spacing; include Abstract, Introduction, Literature Review (minimum 15-20 papers from peer reviewed journals), Main Content, Future Scope, References (IEEE/APA); plagiarism < 20%.
  - Presentation: 12–15 min + 5 min Q&A; 10–15 slides; clear visuals; proper citations.
  - Submission: Hard & soft copy (PPT + PDF) before presentation.

  TW Evaluation (50 Marks):

Sr. No.	Parameter	Marks
1	Literature Review & Understanding	15
2	Content Quality	10
3.	Report & Writing	10
4.	Presentation	10
5.	Question and answers	05
	Total Marks	**50**

- Present and publish a paper in a reputed conference (IEEE/Scopus/ASME) and submit a certificate.
- Patent filling. (Presentation based on patent to be prepared and presented.). The student must produce documents related to patent filing for evaluation.
- Copyright publication (Presentation based on Copyright to be prepared and presented). A copyright grant certificate must be produced at the time of evaluation.

Semester IV

MLC672AID: Introduction to Cybersecurity

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		CCA	ESE				
MLC672AID	4	50	50	--	--	100	4

Course Objectives:	• To give an introduction to cybersecurity. • To help to understand the security requirements of Databases. • To instruct about social networking, fundamental Operating system security. • To give an exposure to practical security methods in cyber domain • To inform about the significance of cyber-crime, tools and methods regarding security aspects.
Course Contents:	**UNIT I Introduction (09 Hours)** Introduction to Cyber Security, Importance and challenges in Cyber Security, Cyberspace, Cyber threats, Cyberwarfare, CIA Triad, Cyber Terrorism, Cyber Security of Critical Infrastructure, Cybersecurity - Organizational Implications.
	UNIT II Hackers and Cyber Crimes (09 Hours) Types of Hackers, Hackers and Crackers, Cyber-Attacks and Vulnerabilities, Malware threats, Sniffing, Gaining Access, Escalating Privileges, Executing Applications, Hiding Files, Covering Tracks, Worms, Trojans, Viruses, Backdoors.
	UNIT III Ethical Hacking and Social Engineering (09 Hours) Ethical Hacking Concepts and Scopes, Threats and Attack Vectors, Information Assurance, Threat Modelling, Enterprise Information Security Architecture, Vulnerability Assessment and Penetration Testing, Types of Social Engineering, Insider Attack, Preventing Insider Threats, Social Engineering Targets and Defense Strategies.
	UNIT IV Cyber Forensics and Auditing (09 Hours) Introduction to Cyber Forensics, Computer Equipment and associated storage media, Role of forensics Investigator, Forensics Investigation Process, Collecting Network based Evidence, Writing Computer Forensics Reports, Auditing, Plan an audit against

	a set of audit criteria, Information Security Management System Management. Introduction to ISO 27001:2013
	UNIT V Cyber Ethics and Laws **(09 Hours)** Introduction to Cyber Laws, Security tools, E-Commerce and E-Governance, Certifying Authority and Controller, Offences under IT Act, Computer Offences and its penalty under IT Act 2000, Intellectual Property Rights in Cyberspace.
Reference Books:	• Donaldson, S., Siegel, S., Williams, C.K., Aslam, A., • Enterprise Cybersecurity -How to Build a Successful Cyber Defense Program Against Advanced Threats, A-press • Nina Godbole, Sumit Belapure, Cyber Security, Willey • Hacking the Hacker, Roger Grimes, Wiley • Cyber Law By Bare Act, Govt Of India, It Act 2000.

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