Course Title	MASS TRANSFER - II	Semester	VI
Course Code	MVJ20CH61	CIE	50
Total No. of Contact Hours	40 L: T: P:: 20 : 10 : 10	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- Be able to understand different separation techniques.
- Acquire the knowledge of separation processes like distillation, adsorption, and extraction.
- Be able to use the phase equilibrium concepts in mass transfer related problems.
- Be able to design staged /packed column for mass transfer operations.
- Be able to design distillation column, absorber and calculations involved in liquid-liquid extraction.

Module-1	RBT Level: L1, L2, L3	8 Hours

Gas Liquid Contacting Systems: Types, construction and working of plate and packed columns, types and properties of industrial packing's, plate efficiencies, HETP and HTU concepts. **Absorption**: Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors.

Experiential Learning: Experiment to study the relationship between the pressure drop and flowrate in Packed bed.

Applications: Students can understand the applications of absorbers in various segments of Chemical Process Industries and to capture acid gases, such as hydrogen chloride and sulphur dioxide, which are released in various processing steps.

Video Links/Any other special information (Papers):

https://nptel.ac.in/courses/103104046/

https://folk.ntnu.no/skoge/prost/proceedings/distillation06/CD-proceedings/paper004.pdf

https://pubs.acs.org/doi/abs/10.1021/ie50180a002

Module-2	RBT Level: L1, L2, L3	8 Hours

Packed Tower Absorption: Liquid phase hold up and pressure drop in absorption towers. Design of packed towers (process design-height and diameter). Multi-component absorption. Absorption with chemical reaction. **Distillation:** Introduction. Vapour liquid equilibria (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component

systems. Non-ideal systems. Azeotropes. Immiscible systems. Atmospheric distillation, Flash and simple distillation, Distillation in a packed tower. **Experiential Learning**: Experiment to verify 'Rayleigh's Equation by differentially distilling the given binary Mixture (SYSTEM: Methanol-Water). To study the characteristics of steam distillation and to determine vaporization efficiency and thermal efficiency. To design the lab scale distillation column to evaluate the concentrations of the components at different points along the column. **Applications:** Students can estimate the composition of distillate and residue using VLE data and explain the different distillation processes in Oil refining, water purification and alcoholic beverage production. **Video Links/Any other special information (Papers)**: https://www.demisterpads.com/demister-pad/packed-tower.html https://nitsri.ac.in/Department/Chemical%20Engineering/Distillation_Notes-PartVI.pdf https://www.youtube.com/watch?v=v1Lx_ZoV5w4		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Distillation (Contd.): Multi-stage rectification column. Design using McCabe Thiele and Lewis-Sorel methods for binary mixtures. **Distillation (Contd.):** Ponchon- Savarit method. Introduction to Multi component distillation, Vacuum, molecular, extractive and azeotropic distillations. **Experiential Learning:** Experimental Study on the Extractive Distillation Based Purification of Second-Generation Bioethanol **Applications:** Helps to understand how to calculate the number of trays in multistage rectification column using McCabe Thiele, Ponchon - Savarit method and Lewis-Sorel methods for multi component and applications in petroleum refineries, petrochemical and chemical plants and natural gas processing plants. **Video Links/Any other special information (Papers)**: https://pubs.acs.org/doi/pdf/10.1021/i200024a001 https://nitsri.ac.in/Department/Chemical%20Engineering/Distillation_Notes-PartIV.pdf http://facstaff.cbu.edu/rprice/lectures/distill6.html		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Liquid-Liquid Extraction: Ternary equilibrium. Solvent selection. Single stage. Multi-stage cross-current, counter-current extraction. Equipment for liquid-liquid extraction, fractional extraction.		

Experiential Learning: Experiment to carry out liquid-liquid Extraction of methyl red from an aqueous layer by three stage cross current operations and in single Stage operations and find the % increase in solute extracted by three stage cross current.

Applications: The technology is used in applications as diverse as ore processing, pharmaceuticals, agriculture, industrial chemicals, petrochemicals, food industry, and purification of base metals and refining of precious metals. Removal of high boiling organics from wastewater Such as phenol, aniline and nitrated aromatics.

Video Links/Any other special information (Papers):

https://unacademy.com/lesson/l65-liquid-liquid-extraction/MC1K89W1

https://nptel.ac.in/courses/103/103/103103154/

https://www.chemengonline.com/liquid-liquid-extraction/

Module-5	RBT Level: L1, L2, L3	8 Hours

Leaching Operation: Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. Calculation of single stage and multi-stage leaching operation.

Experiential Learning: Laboratory Leaching Tests to investigate mobilization and recovery of metals from geothermal reservoirs.

Applications: It helps in understanding the process robustness which governs process productivity and economics. In particular, the pharmaceutical and food sectors are utilizing crystallization for optimized separation, purification, and solid form selection.

Video Links/Any other special information (Papers):

https://www.youtube.com/watch?v=vNFSnxOX0WQ

https://nitsri.ac.in/Department/Chemical%20Engineering/Leaching.pdf

https://ceng.tu.edu.iq/ched/images/lectures/chem-lec/st3/c3/Lectures-Mass%20Transfer-2.pdf

Course outcomes:

CO1	Apply the concepts of HETP, NTU and HTU to design various gas-liquid contacting systems.
CO2	Apply the concept of absorption to calculate the number of plates and height of continuous absorber.
CO3	Estimate the composition of distillate and residue using VLE data and explain the different distillation processes.
CO4	Apply McCabe Thiele, Ponchon - Savarit method and Lewis-Sorel methods for multi component mixtures to calculate no of trays in multi-stage rectification column.
CO5	Develop equations for the material balance for stage wise operations in liquid-liquid extraction and leaching operations and working of the equipment.

Text Books:	
1	Treybal, R. E. (1980). Mass transfer operations. New York, 466.
2	McCabe & Smith. (2001). Unit Operations in Chemical Engineering, 6th edn, McGraw Hill
Reference Books:	
1	Badger, W. L., &Banchero, J. L. (2010). Introduction to chemical engineering. 25th reprint.
2	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., & Andersen, L. B. (2008). Principles of unit operations. John Wiley & Sons.
3	Coulson and Richardson (1988). Chemical Engineering Vol I, II, III, IV and V, 4th edn, Pergamon Press.

Scheme of Evaluation		
Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Activities/ Experimentations related to course (1 in each module)		5X2=10
Assignments / Discussion of Journal papers - 3Nos.		3X2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	-	-	-	-	-	-	-
CO2	3	3	1	2	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	3	3	2	3	-	-	-	-	-	-	-	-
CO5	3	3	1	3	-	-	-	-	-	-	-	-

High-3, Medium-2, Low-1

Course Title	PROCESS EQUIPMENT DESIGN & DRAWING	Semester	VI
Course Code	MVJ20CH62	CIE	50
Total No. of Contact Hours	50 L : T : P :: 30:10:10	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- Understand the chemical engineering principles applicable for designing chemical engineering equipment.
- Apply and use standard codes for design of chemical plant equipment.
- Understand advances and types in the design of heat and mass transfer equipment and its accessories.
- Impart practical knowledge on the shape and drawing of the process equipment (proportionate drawing).

Detailed chemical engineering process design of the following equipment should be studied. The detailed proportionate drawings shall include sectional front view, full top/side view depending on equipment and major components.

Class work: Students have to design the equipment, along with the training to draw free hand proportionate sketches.

Final Examination: Students have to answer any one of the two questions given in the examination. After completing the design, free hand proportionate sketches are to be drawn as required.

Module-1	RBT Level L1, L2, L3	10 Hours

Basic design: Introduction to design, detailed chemical engineering process and mechanical design of the vessel components for Pressure vessel, Jacketed vessel and agitator.

Experiential Learning: Demonstrating the components of various chemical engineering equipment.

Applications: Students can understand the detailed procedure for basic design of common vessel components used in the industry.

Video link / Additional online information:

https://www.youtube.com/watch?v=erW4HZ5I928

https://www.youtube.com/watch?v=WG4l8jpYXKc&list=PLLy_2iUCG87DifDHSUjsn2uYPeIfJ5UIG

Module-2	RBT Level L1, L2, L3	10 Hours

Design of heat exchanger: Types of Heat exchangers, Process design of double Pipe and shell and tube heat exchanger with detailed line diagram.

Experiential Learning: Demonstrating the components of DPHE and STHE.

Applications: To develop and design a detailed HE with modifications as per the industrial requirements.

Video Links/Any other special information:

https://www.youtube.com/watch?v=jbuSc1_M9e4

https://www.youtube.com/watch?v=UZ5yXq07BX0

https://www.youtube.com/watch?v=sgxCq8CDeW4&list=RDCMUCgp23vdLNaUitOkCxxVnRrg&start_radio=1&t=0

Module-3	RBT Level L1, L2, L3	10 Hours

Process design of condenser: Types of condensers, process design of horizontal condenser with detailed line diagram.

Process design of evaporator: Introduction to types of evaporators, methods of feeding of evaporators, general design consideration of single effect evaporator with detailed line diagram

Experiential Learning: Demonstrating the components of horizontal and vertical condensers, evaporators.

Applications: To develop and design horizontal condenser and single effect evaporator with modifications and as per the industrial requirements.

Video Links/Any other special information:

https://www.youtube.com/watch?v=AbA81fLXT4E

https://www.youtube.com/watch?v=dUOgKRUUc3Q

https://nptel.ac.in/content/storage2/courses/103103027/pdf/mod1.pdf

Module-4	RBT Level L1, L2, L3	10 Hours

Process design of distillation column: Design of sieve tray distillation column with the detailed line diagram.

Process design of absorption column: Design of packed bed absorption column with the detailed line diagram.

Experiential Learning: Demonstrating packed bed reactor and its components.

Applications: To develop and design columns for mass transfer operations (distillation and absorption) with modifications and as per the industrial requirements.

Video Links/Any other special information:

https://ceng.tu.edu.iq/ched/images/lectures/chem-lec/st4/c1/EQUIPMENT_DESIGN_LECTURE_25%20mass%20transfer%20equipment%203.pdf

https://nptel.ac.in/content/storage2/courses/103103027/pdf/mod7.pdf		
Module-5	**RBT Level L1, L2, L3**	**10 Hours**
Process design of rotary drier: Classification of dryers, Design of rotary dryer with the detailed line diagram. **Experiential Learning:** \Demonstrating the components of vacuum and tray drier. **Applications:** To develop and design rotary dryer with modifications and as per the industrial requirements. **Video Links/Any other special information:** https://nptel.ac.in/content/storage2/courses/103103027/pdf/mod4.pdf https://www.youtube.com/watch?v=62_WIhwcfQo		

Course outcomes:	
CO1	Understand design procedure of chemical process equipment.
CO2	Apply chemical engineering principles to design chemical process equipment applicable for heat and mass transfer operations.
CO3	Applying the design principles for drying equipments
CO4	Estimate physical dimensions of various parts of columns and their accessories.
CO5	Analyze various design options at all design stages.

Text Books:	
1	S. D. Dawande. (2003). Process Design of Equipment Vol 1 3rd Edition. (Central Techno Publications).
2	Joshi, M. V., &Mahajani, V. V. (2000). Process Equipment Design 3rd Editon.
3	Brownell, L. E., & Young, E. H. (1959). *Process equipment design: vessel design*. John Wiley & Sons.
Reference Books:	
1	Perry, R. H., & Green, D. W. (2008). Prerry's Chemical Engineers Handbook (8th Eds.).
2	Pressure Vessel Code – IS 2825, 4503. (1969). IS Code. (B.I.S., New Delhi).
3	Web Link and Video Lectures: https://nptel.ac.in/courses/103103027/ https://swayam.gov.in/nd1_noc20_ch17/preview

Scheme of Evaluation:

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments (2 Nos.)		5X2=10
Mini projects/Case studies		3X2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	--	1	--	--	--	--	--
CO2	3	3	3	--	--	--	--	--	--	--	--	--
CO3	3	3	3	3	3	--	1	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	1
CO5	3	3	3	--	--	--	--	--	--	--	--	1

High-3, Medium-2, Low-1

Course Title	PETROCHEMICALS	Semester	VI
Course Code	MVJ20CH631	CIE	50
Total No. of Contact Hours	40 L : T : P :: 40 : 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Understand the various types of Carbon compounds and their properties.
- Understand preparation of petrochemical compounds from different sources.

Module-1	RBT Level: L1, L2, L3	8 Hours

Definition Of Petrochemicals: Petrochemical industries in India. Principal raw materials. Introduction to chemicals from C_1, C_2, C_3 and C_4 compounds. **Chemicals From C_1 Compounds:** Manufacture of methanol, formaldehyde and chloromethanes. Manufacture of perchloro ethylene.

Experiential Learning: Demonstrate the manufacturing process of methanol using videos

Application: Manufacture of methanol and chloromethanes and perchloro ethylene in industry

Video Links:

https://www.youtube.com/watch?v=wPox7MUbvqs&t=294s&ab_channel=ChemicalEngineeringGuy

https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod3.pdf

https://nptel.ac.in/courses/103/103/103103029/

Module-2	RBT Level: L1, L2, L3	8 Hours

Chemicals from C_2 Compounds: Feed stock, technology, engineering problems and usage of Ethylene and acetylene, ethanol, Ethylene oxide, polyethylene, acetaldehyde, ethanol amines, acetic acid.

Experiential Learning: Demonstrate the manufacturing process of C_2 Compound using videos.

Application: Manufacture of ethylene, acetylene, ethanol, polyethylene, acetaldehyde, ethanol amines, acetic acid

Video Links:

https://www.youtube.com/watch?v=VxVPDflbVZM&ab_channel=UsmanAhmed

https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod3.pdf

https://nptel.ac.in/courses/103/103/103103029/

Module-3	RBT Level: L1, L2, L3	8 Hours

Chemical from C_3 Compounds: Isopropanol, acetone, Cumene, acrylonitrile, polypropylene,

propylene oxide, Isoprene. **Experiential Learning:** Demonstrate the manufacturing process of C_3 Compound using videos. **Application:** Manufacture of Isopropanol, acetone, acrylonitrile, polypropylene, propylene oxide in industry. **Video Links :** https://www.youtube.com/watch?v=t4Hsue6fNrk&ab_channel=MohannadCobra https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod3.pdf https://nptel.ac.in/courses/103/103/103103029/		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Chemical from C_4 Compounds: Butadiene, dehydrogenation of butane (Houdry). Dehydrogenation of butylenes. Dehydrogenation-dehydration of ethanol. Steam cracking of hydrocarbons. **Chemicals from Aromatics:** Primary raw material. Hydroalkylation. **Experiential Learning:** Demonstrate the manufacturing process of C_4 Compound using videos. **Application:** Manufacture of Butadiene and hydroalkylation process in industry. **Video Links** https://www.youtube.com/watch?v=yCqCxSOG_Y4&t=226s&ab_channel=BillJanzentQuinto https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod3.pdf https://nptel.ac.in/courses/103/103/103103029/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Manufacture of phenol, Styrene, Phthalic anhydride, maleic anhydride, nitrobenzene, aniline. Manufacture of industrial dyes based on petroleum feed stocks. **Experiential Learning:** Demonstrate the production of dye using videos. **Application:** Manufacture of phenol, Phthalic anhydride maleic anhydride, nitrobenzene, aniline in industry **Video Links** https://www.youtube.com/watch?v=A0e0BDEE4Ic&ab_channel=NileRed https://www.youtube.com/watch?v=OeeLWWBTBE&ab_channel=VipulOrganicsLtd. https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod3.pdf https://nptel.ac.in/courses/103/103/103103029/		

Course outcomes:

CO1	Outline petrochemical industry overview in India and manufacturing methods for production of C_1
CO2	Explain different manufacturing methods for production of C_2
CO3	Explain the different method for the production of C_3 compounds

CO4	Explain the different method for the production of C_4 compound and discuss the production of aromatics.
CO5	Illustrate different methods of production of petrochemicals from aromatic compounds and dyes.

Text Books:	
1	Rao, B. K. (1987). A text on petrochemicals.
2	Waddams, A. L. (1969). Chemicals from petroleum.
Reference Books:	
1	Dryden, C. E., Rao, M. G., &Sittig, M. (1973). *Outlines of chemical technology*. Affiliated East-West P.
2	Austin, G. T. (1984). *Shreve's chemical process industries*. McGraw-Hill Companies.

Scheme of Evaluation		
Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments – 2Nos.		5X2=10
Mini Projects/ Case studies - 3Nos.		3X2=6
Semester End Examination	SEE (50)	50
Total		100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	--	--	--	--	1	1	--	--	--	--	--
CO2	3	--	--	--	--	1	1	--	--	--	--	--
CO3	3	--	--	--	--	1	1	--	--	--	--	--
CO4	3	--	--	--	--	1	1	--	--	--	--	--
CO5	3	1	--	--	--	1	1	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	**NANOTECHNOLOGY**	**Semester**	VI
Course Code	MVJ20CH632	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 40 : 0 : 0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3 Hours

Course objective is to:

- Understand the behavior of various smart materials and its applications.
- Understand basics and synthesis of nano materials and their properties.
- Learn to analyze and assess parameters involved in synthesis and characterization.
- Understand the applications of nano technology in various fields.

Module-1	**RBT Level: L1, L2, L3**	**8 Hours**

Introduction and Synthesis of Nano materials: Introduction to nano science and nanotechnologies, importance and its scope, natural nano materials, properties at nano scale (physical, chemical, surface, electrical. magnetic, optical, mechanical), Nano materials: Biomimetic nano materials, Self-assembled nano materials, Nano structured metals and alloys, Polymers, Semiconductors, Ceramic and glassy materials, Carbon-based materials, composites, nano coatings.

Laboratory Sessions/ Experimental learning: Demonstrate the importance of nanotechnology in terms of application and different types of nanomaterials.

Applications: Nanomaterials are widely used in chemical industry, optics, solar hydrogen, fuel cell, batteries, sensors, power generation, aeronautic industry, building/construction industry, automotive engineering, consumer electronics, thermoelectric devices, pharmaceuticals etc.

Video link / Additional online information:

https://www.youtube.com/watch?v=Z51R49OOqAA

https://www.youtube.com/watch?v=tpNiYFv-ldA

Module-2	**RBT Level: L1, L2, L3**	**8 Hours**

Synthesis- Top down and bottom up approach, Ball Milling, laser ablation, Electrodeposition, vapor phase Sputtering, DC/RF Magnetron Sputtering, Thermal Evaporation, sol-gel method, microwave synthesis route, gas, microemulsion method, hydrothermal / Solvothermal Synthesis, ultrasonic method. Photochemical Synthesis, Sonochemical Routes, Chemical Vapor Deposition (CVD) Spray Pyrolysis, Flame Pyrolysis, Molecular Beam Epitaxy

Laboratory Sessions/ Experimental learning: Synthesis of cadmium sulphide nanoparticles by Sol-Gel Method **Applications:** Top down and bottom up methods are used for synthesis of nano material. Video link / Additional online information: https://www.youtube.com/watch?v=HhGCNG2X8gQ https://www.youtube.com/watch?v=Z51R49OOqAA https://www.youtube.com/watch?v=ULY7iprHlLw		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Characterization of Nano materials: Microscopy-Scanning tunneling microscope, Atomic force microscope, scanning electron microscopy, Field Emission Scanning Electron Microscopy, transmission electron microscopy, Environmental Scanning Electron Microscopy (ESEM) High Resolution Transmission Electron Microscope (HRTEM), Surface enhanced Raman Spectroscopy, X-ray diffraction technique, X ray Photoelectron Spectroscopy Surface area analysis, particle size analysis, gravimetric analysis **Laboratory Sessions/ Experimental learning:** Demonstrate the different instruments used for characterization of mano material. Demonstrate the synthesis of Ceria Nanoparticles and Characterize using XRD and SEM analysis. **Applications:** Characterization of prepared nanomaterial is required to determine the surface area, particle size and quantities based on its mass. Video link / Additional online information: Https://www.youtube.com/watch?V=lfys3xdu4fq Https://www.youtube.com/watch?V=iit_KJJ1Uhs Https://www.ufe.cz/en/team/synthesis-and-characterization-nanomaterials		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Nanoscale Manufacturing: Nano manipulation, Nanolithography- Optical lithography, Photolithography, Dip pen nanolithography, Extreme UV Lithography, Electron beam (e-beam) lithography, Epitaxial Growth: classical growth modes, techniques for epitaxy: Liquid Phase Epitaxy (LPE), Physical Vapor Deposition (PVD),Molecular Beam Epitxay (MBE). Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Self-Assembly. **Laboratory Sessions/ Experimental learning:** Circuit fabrication by Manual Lithography Techniques **Applications:** Lithography can be used to print text or artwork onto paper or other suitable material. Lithography originally used an image drawn with oil, fat, or wax onto the surface of a smooth, level lithographic limestone plate.		

Video link / Additional online information:

Https://www.youtube.com/watch?V=nuxdltqfqsa

Https://www.youtube.com/watch?V=nioyljr3ov8

Https://www.youtube.com/watch?V=udxhwvejdj0

Module-5	RBT Level: L1, L2, L3	8 Hours

Application of Nanotechnology: Environment: remediation and mitigation using metal oxide nano particles, magnetic particles, Nanomembranes and nanofilters, Pollution prevention: nanocatalysis, environmental sensors Medicine and healthcare: diagnosis, biosensors, drug delivery, therapy Energy: Solar energy- Photovoltaics, Dye-sensitized solar cell, Quantum-dot- sensitized solar cells. Hydrogen energy- Hydrogen production and Hydrogen storage, hydrogen fuel cell, Energy Savings-Insulators and smart coatings, Energy- harvesting materials, Information and communication technologies: Integrated circuits, Data storage, Photonics, Displays, Information storage devices, Wireless sensing and communication

Laboratory Sessions/ Experimental learning:

Demonstrate the various application of nanotechnology in different sectors.

Applications: Nanotechnology applied in various sector like remediation and mitigation of environmental pollution, medical and health care sector, hydrogen production etc.

Video link / Additional online information:

https://nptel.ac.in/courses/118/102/118102003/

https://onlinecourses.nptel.ac.in/noc19_mm21/preview

Course outcomes:

CO1	Understand the behavior of various smart materials and its applications.
CO2	Identify various nano materials and recall nano materials synthesis, characterization and application.
CO3	Explain the methods of nano material synthesis and characterization
CO4	Apply principles of nano materials in interdisciplinary areas
CO5	Analyze and select synthesis and characterization techniques

Text Books:

1	Varghese, P. I., &Pradeep, T. (2003). *A textbook of nanoscience and nanotechnology*. Tata McGraw-Hill Education.
2	B, Viswanathan; *Nanomaterials*; Narosa Publishing House; First edition; 2010; ISBN: 978-81- 7319-936-3.

Reference Books:

1	Nalwa, H. S. (Ed.). (2001). *Nanostructured materials and nanotechnology: concise edition*. Elsevier.

2	Ratner, M. A., & Ratner, D. (2003). *Nanotechnology: A gentle introduction to the next big idea*. Prentice Hall Professional.
3	Bandyopadhyay, A. K. (2008). *Nano materials*. New Age International.

Scheme of Evaluation:

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes – 3 Nos.		3*2=6
Activities/ Experimentations related to course/ Seminar presentation – 2 Nos.		2*4=8
Mini Projects/ Case studies/Assignments – 3 Nos.		3*2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	--	--	--	3	--	--	--	--	--
CO2	3	2	--	--	--	1	3	--	--	--	--	--
CO3	3	2	--	--	--	1	3	--	--	--	--	--
CO4	3	2	--	--	--	1	3	--	--	--	--	--
CO5	3	2	--	--	--	1	3	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	**BIOCHEMICAL ENGINEERING**	Semester	VI
Course Code	MVJ20CH633	CIE	50
Total No. of Contact Hours	40 L : T : P :: 40 : 00 : 00	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 hrs

Course objective is to:

- Understand and apply the areas of biochemical processes to provide the fundamental background of biological systems.
- Explain the concept of biomolecules and micro-organisms.
- Develop the equations for kinetics of enzymes in different action.
- Enhance knowledge and skills of fermentation processes, Bioreactors and kinetics.

Module 1	**RBT Levels: L1, L2, L3**	**8 Hours**

Introduction: Industrial biochemical processes with typical examples, comparing chemical and biochemical processes. role of a chemical engineer in bioprocess industry. microbiology: structure of cells: prokaryotes and eukaryotes. classification of micro-organisms. taxonomy, control of microorganisms – physical and chemical methods.

Experiential learning: Demonstration of basics of microbiology.

Applications: applications in the field of food microbiology, medical microbiology, industrial microbiology, soil microbiology, water and wastewater microbiology, microbial technology (biotechnology), extraction of metals and environmental microbiology including the use of microorganisms as biosensors.

Video link / Additional online information:

https://www.youtube.com/watch?v=hypSEhoBPKA

Module-2	**RBT Levels: L1, L2, L3**	**8 Hours**

Biochemistry: Chemicals of life: lipids, sugars, polysaccharides, amino acids. vitamins, biopolymers, nucleic acids: RNA, DNA and their derivatives (structure, biological function and importance for life only to be studied).

Enzymes and Proteins: Detailed structure of proteins and enzymes. functions. methods of production and purification of enzymes. nomenclature and classification of enzymes. kinetics and mechanism of enzyme action: Michaelis–Menten, Briggs-Haldane approach. derivation.

Experiential learning: To determine how well an enzyme is working is to measure the rate of its reaction.

Applications: Production of sweetening agents and the modification of antibiotics, they are used in washing powders and various cleaning products, and they play a key role in analytical devices and assays that have clinical, forensic and environmental applications. **Video link / Additional online information:** https://www.youtube.com/watch?v=JxK5rZxbyQY		
Module 3	RBT Levels: L1, L2, L3	8 Hours
Kinetics of Enzyme Action: kinetics of enzyme catalysed reaction. reversible enzyme. two-substrate. experimental determination of rate parameters: batch and continuous flow experiments. Lineweaver–Burk plot, Eadie-Hofstee and Hanes-Woolf plots, batch kinetics (integral and differential methods). **Enzyme Inhibition:** effect of inhibitors (competitive, non-competitive, uncompetitive, substrate and product inhibitions), temperature and pH on the rates enzyme catalysed reactions. determination of kinetic parameters for various types of inhibitions. enzyme immobilization. immobilized enzyme kinetics: effect of external mass transfer resistance. **Experiential learning:** To identify and investigate the action of an enzyme. **Applications:** Enzyme kinetics range from hit finding efforts for new chemical entities on a pharmacological target to concentration effect relationships to large-scale biosynthesis. the study of the science of drug metabolism has two principal concepts-rate and extent. **Video link / Additional online information:** https://www.youtube.com/watch?v=F_N-Xf5BuUQ https://www.youtube.com/watch?v=V8QRP2J4Q-s		
Module-4	RBT Levels: L1, L2, L3	8 Hours
Fermentation Technology: Ideal reactors: a review of batch and continuous flow reactors for bio kinetic measurements. microbiological reactors: operation and maintenance of typical aseptic aerobic fermentation processes. formulation of medium: sources of nutrients. introduction to sterilization of bioprocess equipment. **Growth Kinetics of Microorganisms:** Transient growth kinetics (different phases of batch cultivation). quantification of growth kinetics: substrate limited growth, models with growth inhibitors, logistic equation, filamentous cell growth model. continuous culture: optimum dilution rate and washout condition in ideal chemostat. design and analysis of biological reactors. **Experiential learning:** To study kinetics of growth under batch conditions Apply simple unstructured growth models and obtain the kinetic parameters. **Applications:** Production of alcoholic beverages, for instance, wine from fruit juices and		

beer from grains. potatoes, rich in starch, can also be fermented and distilled to make gin and vodka. fermentation is also extensively used in bread making.

Video link / Additional online information:

https://www.youtube.com/watch?v=5eKdZ0dVCCo

Module-5	RBT Levels: L1, L2, L3	8 Hours

Downstream Processing: Strategies and steps involved in product purification. methods of cell disruption, filtration, centrifugation, sedimentation, chromatography, freeze drying / lyophilization. **Membrane separation Technology:** Reverse osmosis, ultrafiltration, micro filtration, dialysis, final steps in purification, crystallization and drying.

Experiential learning: To demonstrate membrane separations by using virtual lab.

Applications: Identified with downstream processing include purification and recovery of biosynthetic products, mostly pharmaceutics from sources hat are natural. for example, plant and animal tissues or fermentation froth. recycling of components that can be salvaged form waste.

Video link / Additional online information:

https://www.youtube.com/watch?v=Uut1cUs6GpA

Course Outcomes

CO1	Explain structure of cells, nucleic acids, nomenclature, classification and production of enzymes; derive the rate equation by M-M and Brigs-Haldane approach
CO2	Derive rate equation for given enzyme mechanisms and estimate the kinetic rate parameters
CO3	Describe the effects of pH, temperature and inhibitors on enzyme catalysed reactions and explain the methods of enzyme immobilization
CO4	Describe the growth cycle phases for batch cultivation and fed-batch reactors and, derive an expression to determine optimum dilution rate.
CO5	Explain medium formulation, operation & maintenance of fermentation process and strategies and steps involved in product purification.

Text Books:

1	Bailey, J. E., &Ollis, D. F. (2018). Biochemical engineering fundamentals. McGraw-Hill.
2	Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). Principles of fermentation technology. Elsevier.

Reference Books:

1	Shuler, M. L., Kargi, F., &DeLisa, M. Bioprocess Engineering: Basic Concepts, 2001. New York City, NY: Pearson.
2	Das, D., & Das, D. (Eds.). (2019). Biochemical Engineering: An Introductory Textbook. CRC Press.

Scheme of Evaluation

Details	Marks

Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments – 2Nos.		5X2=10
Mini Projects/ Case studies - 3Nos.		3X2=6
Semester End Examination	SEE (50)	50
Total		100

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	--	--	--	--	--	--	--	--	--	--	--
CO2	2	3	--	--	--	--	--	--	--	--	--	--
CO3	3	3	2	--	--	--	--	--	--	--	--	--
CO4	2	3	2	--	--	--	--	--	--	--	--	--
CO5	2	3	2	--	--	1	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PROCESS INSTRUMENTATION	Semester	VI
Course Code	MVJ20CH634	CIE	50
Total No. of Contact Hours	40 L:T:P:: 40:0:0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Understand basic principles of various measuring instruments and its static, dynamic response
- Understand the various instruments utilized to measure the temperature and calculate the temperature using thermometer, thermistor, radiation, and pyrometer.
- Understand to calculate the pressure using manometer and the basic fundamentals of pressure measuring devices
- Study the fundamentals of variable head meter, area flow meter, direct, inertial type level meter and density measurement devices.
- Understand to select suitable measuring device for gas mixture analysis, thermal, electrical conductivity, and viscosity and construct piping and instrumentation diagram.

Module-1	RBT Level: L1, L2, L3	8 Hours

PRINCIPLES OF MEASUREMENT: Analysis- Measurement of Force, Strain and Torque- Use of strain gauges. Transducers - Resistive, capacitive, Inductive and piezoelectric pickups. Static and Dynamic response of Instruments. Errors in measurements.

Experiential learning: Measurement of torque and strain on an object with a strain gauge

Applications: Students can understand the construction and operation of strain gauge. Its primary use is to measure force or strain.

Video Links/Any other special information(Papers):

https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-05(SS)(IA&C)%20((EE)NPTEL).pdf

Module-2	RBT Level: L1, L2, L3	8 Hours

TEMPERATURE MEASUREMENT: Liquid filled, Gas filled and Vapour pressure Thermometers. Bimetallic and Resistance thermometers. Thermocouples and Thermistors. Optical and Radiation pyrometers **Experiential learning**: Expansion of liquid demonstration at various temperature ranges **Applications:** Students can understand the change in size or volume of a given mass with temperature **Video Links/Any other special information(Papers):** https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-04(SS)(IA&C)%20((EE)NPTEL).pdf		
Module-3	RBT Level: L1, L2, L3	8 Hours
Syllabus Content: **PRESSURE MEASUREMENT:** Manometers, Bourdon gauge and Bellow gauge. Measurement of pressure and Vacuum. Use of Transducers. **Experiential learning**: Demonstration on pressure & flow measuring instruments **Applications:** Students will understand how to measure the pressure drop and flow rate which helps to find the Reynolds number and roughness on friction factor and its effects **Video Links/Any other special information (Papers):** https://nptel.ac.in/courses/112/106/112106138		
Module-4	RBT Level: L1, L2, L3	8 Hours
FLOW, DENSITY AND LEVEL MEASUREMENTS: Variable head flow meters. Area flow meters. Positive displacement meters. Pressure Probes. Level measurements - Direct and Inertial types. Measurement of density and specific gravity. Instruments for weighing and feeding. **Experiential learning**: To determine the density of liquids and specific gravity of materials **Applications:** Students will be able to understand the importance of specific gravity and density measurement used to specify and describe a pure substance **Video Links/Any other special information (Papers):** https://nptel.ac.in/content/storage2/courses/101103004/pdf/mod1.pdf		
Module-5	RBT Level: L1, L2, L3	8 Hours
MISCELLANEOUS MEASUREMENTS: Analysis of gas mixtures. Thermal conductivity, Viscosity and Electrical conductivity. Supporting instrumentation - Standard cells, balancing circuits and Terminating devices. Principles of Telemetering. P and I diagrams. **Experiential learning**: Demonstration on miscellaneous measuring instruments **Applications:** Students learn the fundamental operating principle of miscellaneous		

measuring instruments commonly used by scientific workers
Video Links/Any other special information (Papers):
https://nptel.ac.in/courses/103/105/103105130

Course outcomes:

CO1	Explain the basic principles of various measuring instruments and its static, dynamic response. Errors in the measurements.
CO2	Demonstrate the various instruments utilized to measure the temperature and calculate the temperature using thermometer, thermistor, radiation, pyrometer.
CO3	Calculate the pressure using manometer and demonstrate the basic fundamentals of pressure measuring devices
CO4	Demonstrate the fundamentals of variable head meter, area flow meter, direct, inertial type level meter and density measurement devices.
CO5	Select suitable measuring device for gas mixture analysis, thermal, electrical conductivity, viscosity and construct piping and instrumentation diagram.

Text Books:

1	Eckman, D. P. (1967). *Automatic process control*. Wiley.
2	Jain, R. K. (1988). *Mechanical and industrial Measurements*. Khanna Publishers.
3	Benedict, R. P. (1991). *Fundamentals of temperature, pressure, and flow measurements*. John Wiley & Sons.

Reference Books:

1	Perry, R. H., & DW, G. (2007). Perry's chemical engineers' handbook, 8th illustrated ed. *New York: McGraw-Hill*.
2	Considine, D. M. (1985). Process instruments and controls handbook. *New York: McGraw-Hill*.

Scheme of Evaluation:

Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments (2 Nos.)		5X2=10
Seminar (2 Nos.)		2X3=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	--	--	--	--	--	--	--	2	3
CO2	3	2	--	--	--	--	--	--	--	--	2	3
CO3	3	2	--	--	--	--	--	--	--	--	2	3
CO4	3	2	--	--	--	--	--	--	--	--	2	3
CO5	3	2	--	--	--	--	--	--	--	--	2	3

High-3, Medium-2, Low-1

Course Title	PILOT PLANT & SCALE UP STUDIES	Semester	VI
Course Code	MVJ20CH641	CIE	50
Total No. of Contact Hours	40 L : T : P :: 20 : 10 : 10	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Acquire knowledge of prototypes, models, principle of similarity
- Study the physical, static, dynamic, thermal and chemical similarity
- Understand the principle of dimensional analysis and develop differential equation based on physical and chemical laws
- Understand the regime concept and criteria for static dynamic process and extrapolate the process taking into account boundary effect
- Learn to develop scale up techniques for chemical engineering unit operations and process for both batch and continuous process

Module-1	RBT Level: L1, L2, L3	8 Hours

Introduction: concept of prototypes, models, scale ratios, element. principles of similarity: geometric similarity. distorted similarity. static, dynamic, kinematics, thermal and chemical similarity with examples

Dimensional analysis: review of rayleigh's, Buckingham π methods, differential equation for static systems, flow systems, thermal systems, mass transfer processes, chemical processes-homogeneous and heterogeneous

Laboratory sessions/ experimental learning: perform experiments on models of two sizes and demonstrate similarity demonstrate the procedure for the Buckingham π methods

Application: Buckingham π methods and principles of similarity are required for scale up study

Video link / additional online information:

https://www.youtube.com/watch?v=odldy3rlw24&ab_channel=nptelhrd

https://nptel.ac.in/content/storage2/courses/103104043/lecture_pdf/lecture38.pdf

https://nptel.ac.in/content/storage2/courses/112104118/ui/course_home-6.htm

Module-2	RBT Level: L1, L2, L3	8 Hours

Regime concept: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects

Laboratory Sessions/ Experimental learning: Demonstrate the scale criteria of static, dynamic processes

Application: This module is useful for scale up study in static and dynamic process.

Video link / Additional online information:

Https://www.youtube.com/watch?V=k37vpsa3e1g&ab_channel=ronhugo

Https://nptel.ac.in/content/storage2/courses/112101004/downloads/(36-8-1)%20NPTEL%20-%20Vacuum%20Technology.pdf

Https://nptel.ac.in/courses/103/103/103103136/

Module-3	RBT Level: L1, L2, L3	8 Hours

Scale up of unit processes: Chemical reactor systems-Homogeneous reaction systems. Reactor for fluid phase processes catalyzed by solids. Fluid-fluid reactors.

Laboratory Sessions/ Experimental learning: Study of the scale up process of fluidized and packed bed reactor systems.

Application: Scale up of reactor system is used in industries like pharmaceutical for preparing the chemicals.

Video link / Additional online information:

https://www.youtube.com/watch?v=9WSU5X1Mudw&ab_channel=MeghaAnand

https://www.youtube.com/watch?v=h4z979NfmWA

Module-4	RBT Level: L1, L2, L3	8 Hours

Scale up of unit operations: Mixing process, agitated vessel, Stage wise mass transfer processes. Continuous mass transfer processes. Scale up of momentum and heat transfer systems. Environmental challenges of scale up

Laboratory Sessions/ Experimental learning: Scale up study of packed bed system.

Application: Scale up of Mixing process, agitated vessel, Stage wise mass transfer processes. Continuous mass transfer processes, momentum and heat transfer systems for industrial application.

Video link / Additional online information:

https://www.youtube.com/watch?v=PBXYl_EY5vc&ab_channel=Shomu%27sBiology

https://www.youtube.com/watch?v=zrn_oK1kjmI&ab_channel=TheChemoMonster

Module-5	RBT Level: L1, L2, L3	8 Hours

Scale up of bioreactor: Industrial Bioreactor, Purpose of scale up studies in Bioreactor, Parameters involved in scale up of bioreactor, Biological concept of scale up, Basics of scale up

Laboratory Sessions/ Experimental learning: Scale up study of bioreactor

Application: Bioreactor used in Fermentation process

Video link / Additional online information:

Https://onlinecourses.nptel.ac.in/noc21_bt13/preview Https://www.youtube.com/watch?V=Csv_UZWF6oE&ab_channel=thermofisherscientific
Course outcomes:

CO1	Understand scale up in chemical engineering plants and develop relations in terms of dimensionless parameters.
CO2	Provide fundamental background of fluid flow past immersed Bodies and fluidization condition, also illustrate the working of various filtration.
CO3	Scale up of reactors which involves the chemical reaction.
CO4	Understand the Scale up of mixers and heat exchangers, distillation columns and packed towers
CO5	Study the scale up of bioreactor

Text Books:

1	Zlkarnik, M. (2012). *Dimensional analysis and scale-up in chemical engineering*. Springer Science & Business Media.
2	Ibrahim and Kuloor, Pilot Plants and Scale up Studies, IISc

Reference Books:

1	Johnstone, R., & Thring, M. W. (1957). *Pilot plants, models, and scale-up methods in chemical engineering*.
2	Bisio, A., & Kabel, R. L. (1985). *Scaleup of chemical processes: Conversion from laboratory scale tests to successful commercial size design*. New York: Wiley.
2	Ratner, M. A., & Ratner, D. (2003). *Nanotechnology: A gentle introduction to the next big idea*. Prentice Hall Professional.

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes – 2 Nos.		2*2=4
Activities/ Experimentations related to course/ Seminar presentation – 2 Nos.		2*5=10
Mini Projects/ Case studies/Assignments – 3 Nos.		3*2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	--	--	--	--	--	--	--	--	--
CO2	3	3	3	--	--	--	--	--	--	--	--	--
CO3	3	3	3	--	--	--	--	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	--
CO5	3	3	3	--	--	--	1	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PROCESS MODELLING & SIMULATION	Semester	VI
Course Code	MVJ20CH642	CIE	50
Total No. of Contact Hours	40 L:T:P :: 20:20:0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- To give an overview of various methods of process modelling, different computational techniques for simulation.

Module-1	RBT Level: L1, L2, L3	8 Hours

Modelling: Models and model building, principles of model formulations, precautions in model building, Degree-of-freedom analysis, Selection of design variables, Review of numerical techniques, Model simulation.

Review of shell balance approach, continuity equation, energy equation, equation of motion and momentum, transport equation of state equilibrium and Kinetics, thermodynamic correlations for the estimation of physical properties like phase equilibria, bubble and dew points.

Experiential Learning: Mass and Heat transfer balance of PFR, HE, MFR by considering data from current literature.

Applications: Students understands the basic conservation equations and their applications.

Video link / Additional online information:

https://nptel.ac.in/content/syllabus_pdf/103107096.pdf

https://www.youtube.com/watch?v=df5EK1P6Ph0

Module-2	RBT Level: L1, L2, L3	8 Hours

Basic formulation of mathematical modelling: Basic tank model – Level V/s time. **Models in separation process:** Batch Distillation – Vapor composition with time. Multistage distillation and multi component flash drum. Solvent extraction (steady & unsteady state), multistage gas absorption.

Experiential Learning: Tank model experiment and model building for liquid extraction process from current literature.

Applications: Students could be able to develop mathematical equations for chemical Engineering systems.

Video Links/Any other special information:

https://nptel.ac.in/content/syllabus_pdf/103107096.pdf

https://www.youtube.com/watch?v=1a0Ym6DP8EQ&list=PLvpgTFzUKO4_dh8w5DTAbRsJed_yZSi71		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Models in heat transfer operation: Heat conduction through cylindrical pipe (steady & unsteady state), cooling of tanks, and unsteady state heat transfer by conduction. **Models in fluid flow operation:** Fluid through packed bed column, flow & film on the outside of a circular tube, Laminar flow of Newtonian liquid in a pipe, Gravity flow tank. **Experiential Learning:** Model building for Heat Flow through cylindrical pipe and Packed bed column operation by considering current literature. **Applications:** Generating mathematical modelling equations for heat and mass transfer operations. **Video Links/Any other special information:** https://nptel.ac.in/content/syllabus_pdf/103107096.pdf https://www.youtube.com/watch?v=1a0Ym6DP8EQ&list=PLvpgTFzUKO4_dh8w5DTAbRsJed_yZSi71		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Models in reaction engineering: Chemical reaction with diffusion in a tubular reactor, Gas phase pressurized CSTR, Two phase CSTR, reactors in series (Constant and variable hold-ups), Batch reactor with mass transfer. **Experiential Learning:** Modeling and simulation ofreactors in series. **Applications:** Generating mathematical modelling equations for different Chemical reactors. **Video Links/Any other special information:** https://nptel.ac.in/content/syllabus_pdf/103107096.pdf https://www.youtube.com/watch?v=J51llasaows		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
SIMULATION: Simulation of the models, tearing and flow sheeting, Modular and Equation-solving approach (Elementary treatment only). Introduction and use of process simulation software (DWSIM/Aspen Plus/ Aspen Hysys) for flow sheet simulation. **Experiential Learning:** Developing a flowsheet for a known chemical process using DWSIM software. **Applications:** Basic concepts of modelling and flow sheeting. **Video Links/Any other special information:** https://www.youtube.com/watch?v=PXazJmC0MM8 https://nptel.ac.in/content/syllabus_pdf/103107096.pdf		

Course outcomes:	
CO1	Apply the various equations to simple chemical engineering problems.
CO2	Develop the modelling equations for chemical engineering problems pertaining to mass transfer.
CO3	Strategies in developing mathematical models for momentum and heat transfer applications.
CO4	Applying the modelling concepts to the transport problems involving chemical reactions.
CO5	Simulate a process using process simulators (DWSIM/ASPEN Plus/ ASPEN Hysys).

Text Books:	
1	William, L., & William, L. (2003). *Process Modeling Simulation, and Control for Chemical Engineers*. McGraw-Hill Publishing Company.
2	Babu, B. V. (2004). *Process plant simulation*. Oxford University Press, USA.
3	Himmelblau, D. M., & Bischoff, K. B. (1968). Process analysis and simulation: deterministic systems.
Reference Books:	
1	Fogler, H. S. (2001). *Essentials of Chemical Reaction Engineering* Pearson Education.
2	Smith, J. M. and Van Ness, H.C. (1996). Introduction to Chemical Engineering Thermodynamics 5th Edition.
3	Holland, C. D. (1974). Fundamentals and Modelling of Separation Processes: Absorption, Distillation, Evaporation and Extraction. (Englewood Cliffs, Prentice-Hall).

Scheme of Evaluation:

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments (2 Nos.)		5X2=10
Mini project/Case studies		3X2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	--	--	--	--	--	--	--	2
CO2	3	3	3	2	--	--	--	--	--	--	--	1
CO3	3	3	3	2	--	--	--	--	--	--	--	2
CO4	3	3	3	2	--	--	--	--	--	--	--	1
CO5	3	3	3	1	--	--	--	--	--	--	--	1

High-3, Medium-2, Low-1

Course Title	CHEMICAL PROCESS INTEGRATION	Semester	VI
Course Code	MVJ20CH643	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 30 : 10 : 0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3 Hours

Course objective is to:

- Understand process synthesis and analysis based on Pinch concept
- Apply mass & heat exchange networking, to retrofit process and setting up targets for energy and mass minimization.

Module-1	RBT Level: L1, L2, L3	8 Hours

Introduction To Process Integration: Graphical Techniques. Overall mass targeting, direct recycle strategies.

Experiential Learning: Minimizing the waste in the laboratories

Applications: Students can understand the chemical management to minimize the generation of hazardous waste that might adversely affect the environment

Video Links:

https://nptel.ac.in/courses/103/107/103107094/

Module-2	RBT Level: L1, L2, L3	8 Hours

Synthesis Of Mass Exchange Network: Graphical approach, Algebraic approach to targeting direct recycles.

Experiential Learning: Reduce, reuse and recycle lab waste

Applications: Students analyze about minimising the amount of waste we produce, reusing products as much as we can, and remembering to recycle any materials that can be used for a new purpose.

Video Links:

https://nptel.ac.in/courses/103/103/103103035/

Module-3	RBT Level: L1, L2, L3	8 Hours

Algebraic Approach: To targeting mass exchange network, Visualization Strategies: for development of mass integrated system

Experiential Learning: Case studies on Interval based targeting from pollution prevention through mass integration

Applications: The purpose of this case studies is to introduce two novel contributions that can greatly expand the scope of mass integration for pollution prevention

Video Links: https://nptel.ac.in/courses/103/103/103103035/		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Heat Integration: Heat exchanger networks, Graphical and algebraic methods for heat integration, Combined heat and power integration excluding co-generating targeting **Experiential Learning**: Heat Integration in distillation column **Applications:** Students will be able to understand the energy saving in distillation column through adopting heat integration **Video Links:** https://nptel.ac.in/courses/103/107/103107094/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Optimization: Graphical method, simplex method, single variable optimization, multivariable optimization. **Mathematical Techniques**: for synthesis of mass & heat exchange excluding Lingo optimization techniques, for mass integration. Initiatives and applications. Case studies. **Experiential Learning:** Case studies on Chemical Process Industrial Applications **Applications:** Students will able to understand key elements of PI and has motivated you to take initiative and start your own applications to generate value, enhance productivity, reduce pollution, conserve resources and contribute to a sustainable development **Video Links** https://nptel.ac.in/courses/111/105/111105039/		

Course outcomes:

CO1	Solve process integration and direct recycle problems using analytical and graphical techniques
CO2	Solve direct recycle problems using algebraic techniques and to synthesize MEN with pinch analysis.
CO3	Synthesize MEN using algebraic techniques and to solve problems using property integration.
CO4	Apply the concept of pinch analysis to synthesize HENs to find the minimum heating and cooling utilities by graphical & algebraic tools also to synthesize combined heat & power pinch diagrams to solve problems.
CO5	Synthesize MEN and HEN problems using mathematical optimization tools.

Text Books:	
1	El-Halwagi, M. M. (2006). *Process integration*. Elsevier.
2	Smith, R. (2005). *Chemical process: design and integration*. John Wiley & Sons.
Reference Books:	
1	Kemp, I. C. (2011). *Pinch analysis and process integration: a user guide on process integration for the efficient use of energy*. Elsevier.

Scheme of Evaluation		
Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments – 2Nos.		5X2=10
Mini Projects/ Case studies - 3Nos.		3X2=6
Semester End Examination	SEE (50)	50
Total		100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	--	--	--	--	--	--	--	--	3	--
CO2	3	3	--	--	--	--	--	--	--	--	3	--
CO3	3	2	3	3	--	--	--	--	--	--	3	--
CO4	3	3	--	--	--	--	--	--	--	--	3	--
CO5	3	3	3	3	--	--	--	--	--	--	3	--

High-3, Medium-2, Low-1

Course Title	PIPING ENGINEERING & DESIGN	Semester	VI
Course Code	MVJ20CH644	CIE	50
Total No. of Contact Hours	40 L:T:P :: 20:20:0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Understand piping layout and pipe fitting requirements in a process industry.
- Estimate pipe sizing and pressure loss in pipes
- Select material of construction of piping systems
- Identify methods of corrosion protection for the piping
- Suggest different methods of compensation for expansion of pipes

Module-1	RBT Level: L1, L2, L3	8 Hours

Introduction: Fundamentals of Fluid Mechanics: Types of fluid flow, Continuity equation, Bernoulli's equation, and Gas laws.

Hydraulic design considerations: Design considerations for liquid and gas pipelines, Determination of pipe size, economic pipe sizing, pressure losses, measurement of flow in pipes, thrusts in pipelines.

Metallurgy of piping materials: Selection of piping materials, physical properties of pipe materials, recommended piping materials.

Experiential Learning: Demonstration of pipelines and their features in momentum transfer lab.

Applications: Knowledge of basic pipeline elements and concepts relevant to industrial applications.

Video link / Additional online information:

https://www.academia.edu/7466994/PIPING_COURSE_MATERIAL

https://www.youtube.com/watch?v=RpFdpilgrII

Module-2	RBT Level: L1, L2, L3	8 Hours

Pipes and pipe fittings: Codes and Standards, Types of pipe fittings- elbows, crosses, tees, returns, flanges, ends, stubs, reducers, joints, gaskets

Valves and allied fittings: Functions of valves, valve materials and methods of construction, pressure drop in valves, valve size, types of valves, safety relief valve, rupture disks, fire hydrants, and valve operators.

Experiential Learning: Demonstrating of pipe fittings, field trip to any nearby industry.

Applications: Industrial pipeline Engineering concepts. **Video Links/Any other special information:** https://www.academia.edu/7466994/PIPING_COURSE_MATERIAL https://www.youtube.com/watch?v=dieOUwx-33Q		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Pipe supports: Load on supports, primary and secondary supports, types of pipe support: hangers, anchors, racks, trestles, brackets, trunnion, stiffening ribs, pipe clamping, flexible hanger supports, supporting span of pipelines **Experiential Learning:** Demonstrating of pipe supports, field trip to any nearby industry. **Applications:** Industrial pipeline Engineering concepts **Video Links/Any other special information:** https://www.academia.edu/7466994/PIPING_COURSE_MATERIAL https://www.youtube.com/watch?v=U4aUmrOeVbc		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Piping fabrication: Codes and standards, types of piping fabrication, welding joints in pipelines, welding processes used in piping fabrication, preparation of pipe edges, heat treatment of weld joints, inspection of weld joints, repair of defective weld joints **Corrosion erosion in pipelines:** Corrosion control, corrosion reaction, types of corrosion, anticorrosive protective coatings, cathodic protection of pipelines, abrasion. **Experiential Learning:** Demonstrating pipe joints, field trip to any nearby industry. **Applications:** Industrial pipeline Engineering concepts **Video Links/Any other special information:** https://www.academia.edu/7466994/PIPING_COURSE_MATERIAL https://www.youtube.com/watch?v=804DEhNPd64		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Expansion effects and compensating methods: Pipe expansions, methods of compensation, thermal force calculation, methods of compensation, permissible equivalent stresses caused by additional external loads expansion devices calculation of anchor force using a bellow material and life, use of hinged compensators. **Thermal insulation:** Functions of thermal insulators, modes of heat transfer, insulating materials, temperature drop in a pipeline, application of insulation, calculation of condensate, de-superheaters. **Experiential Learning:** Demonstrating types of insulations for pipes, field trip to any nearby industry.		

Applications: Industrial pipeline Engineering concepts

Video Links/Any other special information:

https://www.academia.edu/7466994/PIPING_COURSE_MATERIAL

https://www.youtube.com/watch?v=8q3B85GQKns

Course outcomes:

CO1	Recall the fundamentals of fluid flow, heat transfer, insulation and corrosion.
CO2	Calculate pressure losses in pipes and valves, determine supporting span of pipelines and welding efficiency.
CO3	Apply the codes and standards for pipe sizing, valves, pipe fabrication, corrosion protection and insulation.
CO4	Compare and distinguish amongst materials of construction, pipe fittings, supports, corrosion protection methods and materials of insulation.
CO5	Analyze hydraulic design considerations, losses in valves and fittings, loads on supports, corrosion and insulation considerations.

Text Books:

1	Smith, P. (2013). *The fundamentals of piping design*. Elsevier.
2	Sahu, G. K. (1998). *Handbook of Piping Design*. New Age International.

Reference Books:

1	Nayyar, M. L. (2000). *Piping handbook*. McGraw-Hill Education.
2	Perry, R. H., & Green, D. W. (2008). Prerry's Chemical Engineers Handbook (8th Eds.).
3	Web Link and Video Lectures: https://www.udemy.com/course/fundamentals-of-process-piping-engineering-in-oil-and-gas/ https://www.coursera.org/lecture/natural-gas/pipelines-part-1-xZUE2

Scheme of Evaluation:

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Assignments (2 Nos.)		5X2=10
Mini project/Case studies		3X2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	2	1	2	--	--	--	--	--	--	--
CO2	3	1	1	3	3	--	--	--	--	--	--	--
CO3	1	--	--	--	3	--	--	--	--	--	--	--
CO4	--	--	3	3	2	--	--	--	--	--	--	--
CO5	3	2	2	3	3	2	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	WASTEWATER TREATMENT	Semester	VI
Course Code	MVJ20CH651	CIE	50
Total No. of Contact Hours	40 L : T : P :: 40 : 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- To understand the basic characteristics of wastewater.
- Understand the design and working principle of various treatment methods.
- To know the common methods of treatment in different industries
- To acquire knowledge on operational problems of common effluent treatment plant.

Module-1	RBT Level: L1, L2, L3	8 Hours

Sources, sampling and analysis of wastewater: Water resources. Origin of wastewater. Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Sampling and methods of analysis.

Experiential Learning: Determine the physical, chemical and biological characteristics of wastewater.

Applications: Students can understand the water quality parameters with respective to its BIS standards

Video Links:

https://nptel.ac.in/courses/105/104/105104102/

Module-2	RBT Level: L1, L2, L3	8 Hours

Wastewater treatment: Sedimentation, Coagulation-Flocculation, aerobic, anaerobic, suspended and attached growth systems. Membrane Separation Processes: Reverse Osmosis, Ultra filtration, nanofiltration and desalination.

Experiential Learning: (Experiments which can be conducted on the concepts of contents): Understanding the solid-combustion reactions with real-life examples.

Applications: Students understand the importance of jar test that simulates coagulation/flocculation with differing chemical doses. The purpose of the procedure is

to estimate the minimum coagulant dose required to achieve certain water quality goals. **Video Links:** https://nptel.ac.in/courses/105/105/105105178/		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Water Disinfection Process – Disinfection methodologies and their suitability. Theory of Disinfection and characteristics of good disinfectant. Forms of Chlorination, Chemical reactions, Break point Chlorination. Measurement of Chlorine Demand and residual Chlorine. Estimation of quantity of Chlorine and Bleaching powder required for treatment of water. **Water Softening -** Hardness removal techniques, Studies on effects of hardness. Fluoridation and Defluoridation techniques in affected areas. **Experiential Learning:** Studies on break point chlorination of water **Applications:** Students can able to understand the principal purpose of breakpoint chlorination is to ensure effective disinfection by satisfying the chlorine demand of the water. **Video Links:** https://nptel.ac.in/courses/105/105/105105048/		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Process and treatment of specific industries 1: Manufacturing Process and origin, characteristics, effects and treatment methods of liquid waste from Steel plants, Fertilizers, Textiles, Paper and Pulp industries, Oil Refineries, Coal and Gas based Power Plants. **Experiential Learning:**Study of wastewater effluents characteristics generated from pulp and paper industry **Applications:** Students can be able to understand the physico-chemical characteristics of effluent discharge from paper and pulp industry **Video Links:** https://nptel.ac.in/courses/105/106/105106119/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Process and treatment of specific industries 2: Manufacturing Process and origin, characteristics, effects and treatment methods of liquid waste from Tanneries, Sugar Mills, Distillers, Dairy and Food Processing industries, Pharmaceutical Plants.		

Experiential Learning:	
Characterization of effluents from dairy and food processing industries.	
Applications: Students will be able to understand the physico-chemical characteristics of effluent discharge from dairy and food processing industries	
Video link / Additional online information:	
https://nptel.ac.in/courses/105/106/105106119/	
Course outcomes:	
CO1	Estimate the basic characteristics of wastewater.
CO2	Formulate various treatment methods for wastewater.
CO3	Design a biological treatment process for wastewater.
CO4	Evaluate common effluent treatment methods in various process industries like steel, paper and petroleum.
CO5	Evaluate effluent treatment methods in sugar, food and pharmaceutical industries.
Text Books:	
1	Arceivala, S. J., &Asolekar, S. R. (2006). *Wastewater treatment for pollution control and reuse*. Tata McGraw-Hill Education.
2	Metcalf, L., Eddy, H. P., &Tchobanoglous, G. (1991). *Wastewater engineering: treatment, disposal, and reuse* (Vol. 4). New York: McGraw-Hill.
Reference Books:	
1	Karia, G. L., & Christian, R. A. (2013). *Wastewater treatment: Concepts and design approach*. PHI Learning Pvt. Ltd.
2	Mahajan, S. P. (1985). *Pollution control in process industries*. Tata McGraw-Hill Education.

Scheme of Evaluation:		
Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	**CIE (50)**	30
Quizzes - 2Nos.		2X2=4
Activities/ Experimentations related to course/ Tutorials (1 in each module)		5X2=10
Mini Projects/ Case studies/ Journal Report-2 Nos		6
Semester End Examination	**SEE (50)**	50
Total		100

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	--	--	--	--	3	--	--	--	3	3
CO2	3	3	3	2	--	--	3	--	--	--	3	3
CO3	3	3	2	2	--	--	3	--	--	--	3	3
CO4	3	3	2	2	--	--	3	--	--	--	3	3
CO5	3	3	2	2	--	--	3	--	--	--	3	3

High-3, Medium-2, Low-1

Course Title	COMPOSITE MATERIALS	Semester	VI
Course Code	MVJ20CH652	CIE	50
Total No. of Contact Hours	40 L : T : P :: 40 : 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Understand the significance of advanced materials.
- Differentiate the set of technological properties of the advanced materials with the conventional materials.
- Understand the characteristic properties and usability of composite materials.
- Understand the strength of the composite under transverse & longitudinal loading applications.
- Identify the strengthening mechanics and fabrication techniques adopted in different types of composite material.

Module-1	RBT Level: L1, L2	8 Hours

Introduction: Composite Materials and its Classification. **Synthesis and Fabrication** of advanced and future materials with emphasis on ceramic, Semi-conducting and Superconducting materials with superior structural, optical and electrical properties. Preparation Techniques: Techniques for preparation of ultra-pure, ultra-fine powders: of oxides, nitrides, carbides etc., with very well-defined characteristics and superior properties.

Experiential Learning: Demonstrate the techniques for preparation of ultra-pure, ultra-fine powders.

Applications: Composites are widely used due to their improved mechanical properties, dimensional stability, thermal/chemical stability, and electrical conductivity.

Video Links:

https://nptel.ac.in/courses/112104229/

https://cen.acs.org/articles/82/i35/COMPOSITE-MATERIALS.html

Module-2	RBT Level: L1, L2	8 Hours

Processing Techniques: Techniques such as sintering, hot pressing, hot iso static pressing, tape-casting, sol-gel processing for the formation of monolithic ceramics. Composites (ceramic, ceramic metal, as well as metal matrix). SiO_2. Glasses from above powders.

Experiential Learning: Demonstrate the Sol-gel process

Applications: Processing techniques or heat treatment methods commonly used to increase the strength and structural integrity of a given material. **Video Links:** http://navier.engr.colostate.edu/whatische/ChEL05Body.html https://www.me.iitb.ac.in/~ramesh/courses/ME338/comp.pdf		
Module-3	**RBT Level: L1, L2**	**8 Hours**
Processing Techniques Based on Reaction Methods: such as Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI). Self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibres and semi conducting materials such as Si and Gallium Arsenide **Experiential Learning:** Demonstrate the heat treatment methods to study the physical and chemical properties of materials **Applications:**Techniques based on reaction methods not only to create a solid-state thin film on the surface and produce high-purity bulk materials and powder but also to manufacture composite materials through infiltration techniques. **Video Links:** https://en.wikipedia.org/wiki/Composite_material https://link.springer.com/chapter/10.1007/978-1-4613-2233-7_12		
Module-4	**RBT Level: L1, L2**	**8 Hours**
Synthesis and processing of mixed ceramic oxides with high temperature super conducting properties. Reinforcement, additives, fillers for polymer composite, master batch& compounding. **Experiential Learning:** Demonstration of Compounding for the development of Composite plastic materials with advanced properties. **Applications:** Used in composites to modify materials' properties and tailor the laminate's performance. When added, it improves properties including water resistance, weathering, surface smoothness, stiffness, dimensional stability and temperature resistance. How to solve odour problems in plastics and give electrical and thermal conductivity and antimicrobial properties to materials. **Video Links:** https://freevideolectures.com/course/2266/material-science http://www.plastemart.com/plastic-technical-articles/polymer-compounding-for-developing-advanced-materials/ 2377		

http://compositeslab.com/composite-materials/additives-fillers/		
Module-5	**RBT Level: L1, L2**	**8 Hours**
Polymer composite. Fibre reinforced composites. Stress – Strain modulus relationship Nano composites. Characteristics & applications in marine, aerospace, building &computer industry. Manufacturing methods, hand layouts, filament winding, pultrusion, SMC, DMC. **Experiential Learning:** Demonstrate the different Composite materials **Applications:** Helps in understanding the strengthening mechanics and fabrication techniques adopted in different types of composite material **Video Links:**https://freevideolectures.com/course/3479/processing-of-non-metals/5 https://www.allbro.com/technical-manufacturing-process.html http://www.escm.eu.org/eccm16/assets/0045.pdf		

Course outcomes:	
CO1	Understand the significance of advanced materials.
CO2	Compare the set of technological properties of the advanced materials with the conventional materials.
CO3	Understand the characteristic properties and usability of composite materials.
CO4	Calculate the strength of the composite under transverse & longitudinal loading applications.
CO5	Identify the strengthening mechanics and fabrication techniques adopted in different types of composite material

Text Books:	
1	Kingery, W. D., Bowen, H. K., & Uhlmann, D. R. (1976). *Introduction to ceramics* (Vol. 17). John wiley& sons.
2	Chawla, Kluner (2003). *Advanced Composites.* Academic Publisher.
Reference Books:	
1	Schockelford, J. T. (2020). *Introduction to Material Science for Engineers*. McMillan Publications.
2	Vlack, V. (1959). *Elements Of Material Science And Engineering, 6/E*. Pearson Education India.
3	Nicholas, P. Paul, N., Chermisin off. (1978). *Fibre Reinforced Plastic Deskbook*, Ann Arbor science publishing Inc.

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2 Nos.		2X2=4
Activities/ Experimentations related to course/ Assignment -2 Nos. /Presentation - 1 Nos		3X2=6
Mini Projects/ Case studies/ Journal Report - 2 Nos.		2X5=10
Semester End Examination	SEE (50)	50
Total		100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	--	--	--	--	--	--	--	--	--	--
CO2	2	1	--	--	--	--	--	--	--	--	--	--
CO3	2	1	--	--	--	--	--	--	--	--	--	--
CO4	2	1	--	--	--	--	--	--	--	--	--	--
CO5	2	2	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	INTRODUCTION TO BIOTECHNOLOGY	Semester	VI
Course Code	MVJ20CH653	CIE	50
Total No. of Contact Hours	40 L : T : P :: 40 : 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3hrs

Course objective is to:

- Define biotechnology and list some basic practices.
- Understand the properties of genetic materials and the central dogma of molecular biology.
- Understand genetic engineering and various applications of medical and industrial biotechnology
- Acquire knowledge in plant and animal tissue culture and ethical considerations

Module – 1	RBT Levels: L1, L2, L3	8 Hours

Introduction: The nature of biotechnology, Biotechnology: an interdisciplinary pursuit, Biotechnology: a three-component central core, Substrates for biotechnology, Raw materials and the future of biotechnology, Quality control, product safety, Good Manufacturing Practices and Good Laboratory Practices

Experiential learning: Practical demonstration of substrate preparation for biotechnological research.

Applications: The applications of biotechnology include therapeutics, diagnostics, genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production.

Video link / Additional online information:

https://nptel.ac.in/courses/102/103/102103045/

https://ocw.mit.edu/courses/biology/7-012-introduction-to-biology-fall-2004/video-lectures/lecture-1-introduction/

Module – 2	RBT Levels: L1, L2, L3	8 Hours

Introduction to Molecular biology: DNA and RNA composition and structure, DNA replication, recombination and repair, transcription and translation, regulation of gene expression.

Experiential learning: To demonstrate the mechanism of DNA replication, transcription and translation using videos.

Applications: Disease prevention and treatment, generation of new protein products, and manipulation of plants and animals for desired phenotypic traits are all applications of molecular biology methods.

Video link / Additional online information:

https://nptel.ac.in/courses/102/103/102103045/

https://ocw.mit.edu/courses/biology/7-012-introduction-to-biology-fall-2004/video-lectures/lecture-10-molecular-biology-1/

Module-3	RBT Levels: L1, L2, L3	8 Hours

Genetic Engineering: Introduction to genetic engineering, basic techniques in genetic engineering, polymerase chain reaction, gene libraries, protein engineering, manipulation of gene expression in host cell, human genome project.

Experiential learning: Demonstrate polymerase chain reaction using videos.

Applications: In medicine, genetic engineering has been used to mass-produce insulin, human growth hormones, follistim (for treating infertility), human albumin, monoclonal antibodies, antihemophilic factors, vaccines, and many other drugs.

Video link / Additional online information:

https://nptel.ac.in/courses/102/103/102103045/

https://ocw.mit.edu/courses/biology/7-012-introduction-to-biology-fall-2004/video-lectures/lecture-6-genetics-1/

Module-4	RBT Levels: L1, L2, L3	8 Hours

Medical and Industrial Biotechnology: Gene therapy, DNA in disease diagnosis and medical forensics, recombinant vaccines, monoclonal antibodies, Fermentation and enzyme technology, downstream processing, microbial production of antibiotics.

Experiential learning: To demonstrate the microbial production of antibiotics using videos.

Applications: Recombinant Insulin, Gene Therapy, Molecular Diagnosis, Pharmacogenomics, Edible Vaccines are the medical BT applications. Production of value-added products is the main application of industrial BT.

Video link / Additional online information:

https://nptel.ac.in/courses/102/103/102103045/

https://www.youtube.com/watch?v=SE7Fi8jM8ho

Module-5	RBT Levels: L1, L2, L3	8 Hours

Animal, Plant and Environmental Biotechnology: Fundamentals of animal cell culture, transgenic animals, Fundamentals of plant cell culture, transgenic plants, sludge treatment, biodegradation and bioremediation.

Public perception of Biotechnology: genetic engineering – safety, social, moral and ethical considerations
Experiential learning: To determine the percentage moisture content present in the different solid waste samples.
Applications: Plant-derived proteins, therapeutic proteins, transgenic products, biotreatments.
Video link / Additional online information: https://nptel.ac.in/courses/102/103/102103045/ https://www.digimat.in/nptel/courses/video/102106080/L01.html

Course Outcomes:	
CO1	Explain biotechnology as a foundation in biology with engineering of living systems and its nature and practices.
CO:	Illustrate the storage of genetic information and its translation at molecular level.
CO3	Explain the molecular techniques involved in isolation and manipulation of genetic material.
CO4	Explain the medical and industrial applications of biotechnology.
CO5	Discuss the techniques of Plant and animal cell Culture, biodegradation and public perception of biotechnology.

Scheme of Evaluation:		
Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes - 2Nos.		2X2=4
Activities/ Experimentations related to course/ Assignment -2 Nos. /Presentation- 1 Nos		3X2=6
Mini Projects/ Case studies/ Journal Report - 2 Nos.		2X5=10
Semester End Examination	SEE (50)	50
Total		100

Text Books:	
1	Satyanarayana, U. (2008). Text book of biotechnology. Books & Allied Ltd, Kolkata.
2	Smith, J. (2004). Biotechnology (4th ed., Studies in Biology). Cambridge: Cambridge University Press. doi:10.1017/CBO9781139167215
Reference Books:	
1	Lewin, B. (2004). Genes Viii (No. 04; QH430, L4.).
2	Primrose, S. B., & Twyman, R. (2013). Principles of gene manipulation and genomics. John Wiley & Sons.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	--	--	--	3	3	3	--	--	--	--
CO2	2	2	--	--	--	3	3	3	--	--	--	--
CO3	2	2	--	--	--	3	3	3	--	--	--	--
CO4	3	2	--	--	--	3	3	3	--	--	--	--
CO5	2	2	--	--	--	3	3	3	--	--	--	--

High-3, Medium-2, Low-1

Course Title	INDUSTRIAL SAFETY	Semester	VI
Course Code	MVJ20CH654	CIE	50
Total No. of Contact Hours	40 L : T : P :: 20 : 10 : 10	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Learn about implementation of safety procedures, risk analysis and assessment, hazard identification
- Understand the basics of risk assessment methodologies
- Relate safety, ergonomics and human factors

Module-1	RBT Level: L-1, L-2, L3	8 Hours

Need for safety in industries; Safety Programmes – components and realization; Potential hazards – extreme operating conditions, toxic chemicals; safe handling. Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; promotion of industrial safety

Laboratory Sessions/Experimental Learning: Demonstration of Awareness of Industrial Safety including implementing safety protocols, having right tools and regular equipment inspections.

Applications: Industrial safety is needed to check all the possible chances of accidents for preventing loss of life and permanent disability of any industrial employee, any damage to machine and material. It is needed to prevent accidents in the industry by reducing any hazards.

Video link / Additional online information:

https://nptel.ac.in/courses/110105094/

https://fens.sabanciuniv.edu/sites/fens.sabanciuniv.edu/files/lab-safety/labsafety_web.pdf

https://www.ors.od.nih.gov/sr/dohs/safety/laboratory/Pages/student_goodlab.aspx

Module-2	RBT Level: L-1, L-2, L3	8 Hours

General Risk Identification Methods: Hazard identification methodologies, risk assessment methods- PHA, HAZOP, MCA, consequence analysis, hazards in workplaces- nature and type of workplaces, types of hazards, hazards due to improper housekeeping, hazards due to fire in multi floor industries and buildings.

Laboratory Sessions/Experimental Learning: Development of SOPs for repetitive procedures which are known to have associated hazards where injury, property loss, or productivity loss could result if the steps were not followed precisely.

Applications: Provides assessment approaches that are intended to be relatively easy to implement and use. **Video link / Additional online information:** https://nptel.ac.in/courses/103106071/		
Module-3	RBT Level: L-1, L-2, L3	8 Hours
Risk Assessment and Management Methods: Risk adjusted discounted rate method, certainty equivalent coefficient method, probability distribution, Shackle approach, Hiller"s model, Hertz Model. Emergency relief Systems, Diers program, bench scale experiments, design of emergency relief systems, risk management plan, risk management alternatives, risk management tools & plans, risk index method, Dowfire and explosion method, Mond index Method. **Laboratory Sessions/Experimental Learning:** Demonstration of Risk Identification methods, defined levels of hazards based on risk assessment. **Applications:** Many activities in the process industries involve handling hazardous chemicals, some of which are major hazards. Incidents in which there is loss of containment of such chemicals can have consequences which are potentially harmful to people and the environment. Hence there is the possibility of some risk to people and the environment on or around certain process industry activities. **Video link / Additional online information:** http://www.cholarisk.com/downloads/about-pdf/Risk-Management-for-Chemical-Industries.pdf https://ptgmedia.pearsoncmg.com/images/9780131382268/samplepages/0131382268.pdf		
Module-4	RBT Level: L-1, L-2, L3	8 Hours
Risk Assurance and Assessment: Property insurance, transport insurance, liability insurance, risk Assessment, low Probability high consequence events. Fault tree analysis, Event tree analysis. **Laboratory Sessions/Experimental Learning:** Demonstration of graphical methods like Fault tree analysis, event tree analysis that illustrates combinations of failures that will cause one specific failure of interest. **Applications:** It helps in understanding the typical stages in Risk Management approach like Identify, Understand and evaluate, assess, select, implement, monitor and review, communicate.		
Module-5	RBT Level: L-1, L-2	8 Hours

Risk Analysis in Chemical Industries: Handling and storage of chemicals, process plants, personnel protection equipment's. International environmental management system. **Fire Safety & Precautions:** Introduction, Fire alarms and detectors, Fire extinguishers, Emergency escape and firefighting. Industrial Safety.   **Laboratory Sessions/Experimental Learning:** Demonstrate hazard identification, hazard evaluation, and hazard mitigation in laboratory operations   **Applications:** Risk assessment is a custom of evaluating the potential scope or considered action which might lead to an undesired outcome. To carry out a Risk Analysis, you must first identify the possible threats that you face, and then estimate the likelihood that these threats will materialize.   **Video link / Additional online information:**   https://www.mindtools.com/pages/article/newTMC_07.htm   https://hal-ineris.archives-ouvertes.fr/ineris-00961858/document

Course outcomes:	
CO1	Demonstrate the awareness of plant safety in selection and layout of chemical plants and the usage of safety codes.
CO2	Analyse various risk identification methods
CO3	Interpret the various risk assessment tools in process industries
CO4	Analyze tools and safety procedures for protection into health hazards and to implement the effective process control and instrumentation.
CO5	Analyze various precautions for handling and storage of chemicals in process industries.

Text Books:	
1	Handley, W. (1977). *Industrial safety handbook*. McGraw-Hill Companies.
2	Daren Rodney - Safety in the Workplace: Guide to Health and Safety in the workplace, 2020
Reference Books:	
1	Crowl, D. A., &Louvar, J. F. (2001). *Chemical process safety: fundamentals with applications*. Pearson Education.
2	Jenkins, S. (2013). *Functional Safety in the Process Industry: A Handbook of Practical Guidance in the Application of IEC61511 and ANSI/ISA-84*. Chemical Engineering, 120(1), 10-11.

3	Wilson, L., McCutcheon, D., & Buchanan, M. (2003). *Industrial safety and risk management*. University of Alberta.

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., ∑ (Marks Obtained in each test)/3	CIE (50)	30
Quizzes – 2 Nos.		2*2=4
Activities/ Experimentations related to course/ Seminar presentation – 2 Nos.		2*5=10
Mini Projects/ Case studies/Assignments – 3 Nos.		3*2=6
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	--	1	--	1	1	--	--	--	1	--
CO2	2	3	1	--	1	1	--	--	--	--	--	--
CO3	2	3	1	--	1	1	--	--	--	--	--	--
CO4	3	--	1	--	--	--	--	--	1	--	1	--
CO5	3	3	1	--	1	1	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MASS TRANSFER LAB	Semester	VI
Course Code	MVJ20CHL66	CIE	50
Total No. of Contact Hours	40 L: T : P :: 0: 10 : 30	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to:

- To verify experimentally the mass transfer concepts studied in theory.
- To carry out experiment and make observations for various mass transfer equipment.
- To study the effect of mass transfer coefficients in design of equipment.
- To evaluate the performance characteristic for different mass transfer cases.

S. No.	Experiment Name	RBT Level	Hours
1	Determination of diffusivity	L1, L2, L3, L4	3
2	Verification of Rayleigh's equation by conducting simple distillation	L1, L2, L3, L4	3
3	Determination of HETP using packed column distillation	L1, L2, L3, L4	3
4	Study the characterization of steam distillation	L1, L2, L3, L4	3
5	Solid – liquid leaching: Single stage and three stage cross current	L1, L2, L3, L4	3
6	Verification of Himus equation	L1, L2, L3, L4	3
7	Study the drying characteristics in a tray dryer	L1, L2, L3, L4	3
8	Adsorption studies: single stage and two stage cross-current operation	L1, L2, L3, L4	3
9	Determination of Vapour Liquid Equilibrium (VLE)data	L1, L2, L3, L4	3
10	Liquid extraction: single stage and three stage cross current operation	L1, L2, L3, L4	3
11	Hold up studies in packed columns	L1, L2, L3, L4	3
12	Study the drying characteristics in a vacuum dryer	L1, L2, L3, L4	3
13	Determination of mass transfer coefficient by conducting wetted wall column experiment	L1, L2, L3, L4	3
14	Measurement of cooling tower characteristic parameter	L1, L2, L3, L4	3
15	Solid dissolution Studies	L1, L2, L3, L4	3

16	Separation of DNA using Gel-electrophoresis experiment	**L1, L2, L3, L4**	**3**
17	Casting of membrane	**L1, L2, L3, L4**	**3**

Course outcomes:	
CO1	Determine the diffusivity of organic vapors in air using Arnold cell & verify Himus equation using surface evaporation.
CO2	Determine stage efficiency for adsorption, leaching & extraction.
CO3	Estimate parameters affecting distillation using simple distillation, packed column/ plate column distillation & steam distillation and drying time in atmospheric and vacuum dryer.
CO4	Determine the specific rate of dissolution & transfer coefficient for given solid and mass transfer coefficient for air-water vapour system for various conditions using wetted wall column.
CO5	Estimate the height of cooling tower for given situation & verify vapour liquid equilibrium.

Details		**Marks**
Regular Lab work	**CIE (50)**	**20**
Record writing		**5**
Lab tests (minimum 2 tests shall be conducted for 15 marks and average of two will be taken)		**15**
Viva		**10**
Examinations will be conducted for 100 marks and scaled- down to 50	**SEE (50)**	
Write up		**10**
Conduction		**20**
Analysis of results		**10**
Viva		**10**
	Total	**100**

Text Books:	
1	Treybal, R. E. (1980). Mass transfer operations. New York, 466.
2	McCabe & Smith. (2001). Unit Operations in Chemical Engineering, 6th edn, McGraw Hill
Reference Books:	

1	Geankoplis, C. J. (2003). Transport processes and separation principles (include unit operation).
2	Coulson and Richardson (1988). Chemical Engineering Vol I, II, III, IV and V, 4th edn, Pergamon Press.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	2	-	-	-	-	3	-	-	-
CO2	3	3	-	2	-	-	-	-	3	-	-	-
CO3	3	3	-	2	-	-	-	-	3	-	-	-
CO4	3	3	-	2	-	-	-	-	3	-	-	-
CO5	3	3	-	2	-	-	-	-	3	-	-	-

High-3, Medium-2, Low-1

Course Title	COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING LABORATORY	Semester	VI
Course Code	MVJ20CHL67	**CIE**	50
Total No. of Contact Hours	20	**SEE**	50
No. of Contact Hours/week	3 L:T:P::0:10:10	**Total**	100
Credits	2	**Exam. Duration**	3 Hours

Course objective is to:

Students will learn to use mathematical tools to solve chemical engineering problems and basic programming in MATLAB.

The following experiments are to be carried out; the data are to be analysed based on the theoretical aspects and recorded with comments.

Sl No	Experiment Name	RBT Level	Hours
1.	MATLAB – Matrices/ Polynomials/ Integral/ Differential/Plots	L1, L2, L3, L4	3
2.	Data handling and regression using MS-Excel	L1, L2, L3, L4	3
3.	Non-linear algebraic equation – Newton's method	L1, L2, L3, L4	3
4.	Solving a process flowsheet (material balance) using MS-Excel	L1, L2, L3, L4	3
5.	Numerical Integration- Simpson's 1/3 Rule	L1, L2, L3, L4	3
6.	Ordinary Differential Equation- R-K Method	L1, L2, L3, L4	3
7.	Curve Fitting-Least Square	L1, L2, L3, L4	3
8.	Calculation of Bubble Point and Dew Point for Ideal multi-component system	L1, L2, L3, L4	3
9.	P-x,y and T-x,y data generation from the given vapor pressure data	L1, L2, L3, L4	3
10.	Flash Vaporization for multi-component system	L1, L2, L3, L4	3
11.	Design of Batch Reactor/PFR/CSTR	L1, L2, L3, L4	3
12.	Double pipe heat exchanger (Area, Length and Pressure drop)	L1, L2, L3, L4	3

Note:

- Minimum of 10 experiments are to be conducted and all 10 experiments are to

	included for practical examination.
Course outcomes:	
CO1	Solve chemical engineering problems by using numerical methods
CO2	Write programs in MATLAB for solving problems using computational techniques and execute them in laboratory.
CO3	Analyse and interpret data using MS-Excel
CO4	Solving chemical reactors design using numerical methods
CO5	Design heat and mass transfer equipment using numerical methods.

Scheme of Evaluation:

Details		Marks
Daily Evaluation	CIE (50)	30
Internal Assessment		10
Project Based Experiment		10
Semester End Examination	SEE (50)	50
	Total	100

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	--	3	--	--	--	--	--	--	2
CO2	3	3	3	--	3	--	--	--	--	--	--	2
CO3	3	3	3	--	3	--	--	--	--	--	--	2
CO4	3	3	3	--	3	--	--	--	--	--	--	--
CO5	3	3	3	--	3	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MINI PROJECT	Semester	VI
Course Code	MVJ20CHP68	CIE	50
Total No. of Contact Hours	L : T : P :: 0 : 0 : 60	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course Objective:

- To support independent learning.
- To develop interactive, communication, organization, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgment, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instill responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

MINI PROJECT: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

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

CO1	Describe the project and be able to defend it. Develop critical thinking and problem solving skills.
CO2	Learn to use modern tools and techniques. Communicate effectively and to present ideas clearly and coherently both in written and oral forms.
CO3	Develop skills to work in a team to achieve common goal. Develop skills of project management and finance.
CO4	Develop skills of self-learning, evaluate their learning and take appropriate actions to improve it.
CO5	Prepare them for life-long learning to face the challenges and support the technological changes to meet the societal needs.

Scheme of Evaluation :

Internal Marks: The Internal marks (50 marks) evaluation shall be based on Phase wise completion of the project work, Project report, Presentation and Demonstration of the actual/model/prototype of the project.
Semester End Examination: SEE marks for the project (50 marks) shall be based on Project report, Presentation and Demonstration of the actual/model/prototype of the project, as per the norms by the examiners appointed

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	3	3	2	1	1	2	1	1	2
CO2	2	2	2	3	3	2	1	1	2	1	2	2
CO3	2	2	2	3	3	2	1	1	2	1	2	2
CO4	2	2	2	3	3	2	1	1	2	1	2	2
CO5	2	2	2	3	3	2	1	1	2	1	2	2

High-3, Medium-2, Low-1