Course Title	FOURIER SERIES, TRANSFORMS, NUMERICAL AND OPTIMIZATION TECHNIQUES	Semester	III
Course Code	MVJ20MCH31	CIE	50
Total No. of Contact Hours	40 L : T : P :: 20 : 20 : 00	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course Objective is to: This course will enable students to

- Comprehend and use of analytical and numerical methods in different engineering fields
- Apprehend and apply Fourier Series
- Realize and use of Fourier transforms and Z-Transforms
- Use of statistical methods in curve fitting applications
- Use of numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variation

Module-1	RBT Levels: L1, L2 & L3	8 Hours

Laplace Transforms: Definition and Laplace transforms of Elementary functions. Laplace transforms of $e^{at}f(t), t^n f(t)$ and f(t)/t , periodic functions and unit step function – problems.

Inverse Laplace Transforms: Inverse Laplace Transforms – Problems, Convolution theorem to find the inverse Laplace transforms and problems, solution of linear differential equations using Laplace Transforms.

Applications: The Laplace transform is particularly useful in solving linear ordinary differential equations.

Video link / Additional online information (related to module if any):

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

https://www.youtube.com/watch?v=Pq-tUQzeSRw

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

Fourier Series: Periodic functions, Dirichlet's condition, Fourier Series of periodic functions with period 2π and with arbitrary period $2c$. Fourier series of even and odd functions. Half range Fourier Series, Practical harmonic Analysis.

Applications: The Fourier series has many such applications in harmonic analysis, vibration analysis, acoustics, optics etc.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=4N-IwHUCFa0

https://www.youtube.com/watch?v=UGuOVeoo3QE

https://www.youtube.com/watch?v=x04dnqg-iPw

https://nptel.ac.in/courses/111106111/

Experimental learning (Videos):

http://esg.mit.edu/videos/fourier-series-modeling-nature/

https://www.khanacademy.org/science/electrical-engineering/ee-signals/ee-fourier-series/v/ee-fourier-series-intro

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

Fourier transforms:

Infinite Fourier transform, Infinite Fourier sine and cosine transforms, Inverse Fourier transforms, Inverse Fourier sine and cosine transforms, Convolution theorem and problems.

Applications: Fourier Transformation (FT) has huge application in studying to study vibrations in building/structures. Any kind of spectroscopy applied in chemical engineering (CE) is based in Fourier techniques.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=spUNpyF58BY

https://www.youtube.com/watch?v=6spPyJH6dkQ

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

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

Numerical Methods: Numerical solution of ordinary differential equations of first order and first degree, Taylor's series method, modified Euler's method. Runge - Kutta method of fourth order, Milne's and Adams-Bash forth predictor and corrector methods (No derivations of formulae-single step computation only.

Applications: Numerical Methods are used to provide 'approximate' results for the differential equation problems being dealt with and their necessity is felt when it becomes impossible or extremely difficult to solve a given problem analytically.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=QugqSa3Gl-w

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

Numerical Methods: Numerical solution of second order ordinary differential equations, Runge-Kutta method and Milne's method. (No derivations of formulae-single step

computation only). **Optimization Techniques:**

Linear Programming, Mathematical formulation of linear programming problem (LPP), Types of solutions, Graphical Method, Simplex Method.

Applications:

Linear Programming is used in a variety of fields including food and agriculture, engineering, transportation problems, manufacturing and energy.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=v63aU0TVFkw

Course outcomes:

CO1	Use Laplace transform and inverse transforms techniques in solving differential equations.
CO2	Know the use of periodic signals and Fourier series to analyze circuits and system
CO3	Demonstrate Fourier Transform as a tool for solving Integral equations.
CO4	Identify appropriate numerical methods to solve ODE.
CO5	Solve the mathematical formulation of linear programming problem.

Text Books:

1	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2	S. D. Sharma, "Operations Research", Kedar Nath and Ram NathPublishers, Seventh Revised Edition 2014.

Reference Books:

1	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
2	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition
3	Jain R. K.& Iyengar S.R.K., Advanced Engineering Mathematics, Narosa Publishing House, 2002.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (10 marks)
- Assignments (10 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	3	0	0	0	0	0	0	0	1
CO2	3	3	0	3	0	0	0	0	0	0	0	0
CO3	2	3	0	3	0	0	0	0	0	0	0	1
CO4	3	3	0	3	0	0	0	0	0	0	0	0
CO5	3	3	0	2	0	0	0	0	0	0	1	1

High-3, Medium-2, Low-1

Course Title	CHEMICAL PROCESS CALCULATION	Semester	III
Course Code	MVJ20CH32	CIE	50
Total No. of Contact Hours	50 L : T : P :: 40 : 10 : 0	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- Learn basic laws about the behavior of gases, liquids and solids.
-

Applications: Psychometry knowledge will help to understand refrigeration concept related to mechanical engineering. The material balance of unit operation will help in the design and simulation of those processes.

Video link / Additional online information:

https://nptel.ac.in/courses/103103165/

https://youtu.be/SUys-sqi0rQ

https://www.youtube.com/watch?v=XtfBYZuA7rI

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

Typical steady state material balances on evaporation, absorption and leaching and problems. Steady State Material Balance with Reaction: Principles of stoichiometry, Concept of limiting and excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, Selectivity, related problems.

Laboratory Sessions/ Experimental learning: Demonstrate the concept of adsorption and leaching by conducting simple experiments in mass transfer lab.

Show the working of Single effect evaporator in the Heat transfer lab.

Applications: The material balance of unit operation and processes will help in the design and simulation of those processes. It enables them to understand the raw materials required, yield etc of a given process.

Video link / Additional online information:

https://nptel.ac.in/courses/103103165/

https://youtu.be/p72wC36W83Q

https://nptel.ac.in/courses/102106069/

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

Fuels and Combustion: Ultimate and Proximate analysis of fuels, Material balances on combustion processes: Material balances based on combustion reactions, Solving problems. Material balances with and without reactions involving bypass, recycle and purging.

Laboratory Sessions/ Experimental learning: Experiment with reactions in simple reactor to understand the concept of limiting reactant, conversion & Excess reactant.

Applications: Fuel characteristics and its effectiveness in heating purposes can be applied various mechanical as well as chemical fields

Video link / Additional online information:

https://nptel.ac.in/courses/103103165/

https://youtu.be/N9du6edNgqc

https://youtu.be/WhypzrXOVXQ

https://nptel.ac.in/courses/102106069/

Module-5	RBT Level: L1, L2, L3	10 Hours

Energy balance: Thermo physics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions. Kopp's rule, latent heats, heat of fusion and heat of vaporization, Trouton's rule, latent heat of vaporization using Clausius - Clapeyron equation. **Thermo chemistry:** Calculation and applications of heat of reaction, combustion, formation, Kirchhoff's equation, Effect of temperature on heat of reaction. Adiabatic and non-adiabatic reactions. Theoretical and actual flame temperatures.

Laboratory Sessions/ Experimental learning: Demonstrate working of bomb calorimeter to understand the fuel heat capacity measurement

Applications: Energy balance concept can be applied in any energy required processes and is basic step in chemical process design.

Video link / Additional online information:

https://nptel.ac.in/courses/103103165/

https://youtu.be/0H0OpEsG8ak

https://nptel.ac.in/courses/102106069/

Course outcomes:

CO1	Comprehend the basic theories in stoichiometry and perform unit conversions and calculations.
CO2	Solve material balance problems of steady state unit operations like drying, mixing, evaporation, distillation, humidification etc.
CO3	Apply material balance concept to solve multistage operations like bypass, recycle and purging
CO4	Apply the concept of material balance for process with reactions.
CO5	Explain the concepts of thermo physics and thermo chemistry and solve steady state enthalpy balance problems

Text Books:

1	Himmelblau, D. M., & Riggs, J. B. (2012). *Basic principles and calculations in chemical engineering*. FT press.
2	Felder, R. M., Rousseau, R. W., & Bullard, L. G. (2020). *Elementary principles of chemical processes*. John Wiley & Sons.

Reference Books:

1	Bhatt, B. I., & Thakore, S. B. (2010). *Stoichiometry*. Tata McGraw-Hill Education.
2	Hougen, O. A., Watson, K. M., & Ragatz, R. A. (1962). *Chemical Processes Principles. Part I: Material and Energy Balances*. John Wiley and Sons.

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.		10
Mini Projects/ Case studies/Assignments – 3 Nos.		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	--	--	--	--	--	--	--	--	1
CO2	3	3	3	--	--	--	--	--	--	--	--	--
CO3	3	3	3	--	--	--	--	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	--
CO5	3	3	3	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MOMENTUM TRANSFER	Semester	III
Course Code	MVJ20CH33	CIE	50
Total No. of Contact Hours	40 L:T:P:: 20:20:00	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- Understand concepts on nature of fluids, type of fluid flow and boundary layer relations, pressure concepts and its measurement by various experimental methods and enhancement of problem-solving skills.
-

Video link / Additional online information: http://vlabs.iitb.ac.in/vlab/chemical/exp1/index.html		
Module-2	**RBT Level: L1, L2, L3**	**8 Hours**
Basic equations of fluid flow: Average velocity, Mass velocity, Continuity equation, Euler and Bernoulli equations Modified equations for real fluids with correction factors, Pump work in Bernoulli equation, Angular momentum equation. **Flow of incompressible fluids in conduits and thin layers:** Laminar flow through circular and non-circular conduits, Hagen Poiseuille equation, Laminar flow of Non-Newtonian liquids, Turbulent flow in pipes and closed channels. **Experiential Learning:** Experimentation to verify the generalized correlation between Reynolds number and friction factor in Annulus, circular and non-circular pipes. **Applications:** To analyse the flow patterns of incompressible fluids in various conduits. **Video Links/Any other special information:** http://uorepc-nitk.vlabs.ac.in/exp1/index.html		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Flow of incompressible fluids in conduits and thin layers (contd...): Friction factor chart, friction from changes in velocity or direction, Form friction losses in Bernoulli equation, Flow of fluids in thin layers. **Flow of compressible fluids:** Continuity equation, Concept of Mach number, Total energy balance, Velocity of sound, Ideal gas equations, Flow through variable-area conduits, Adiabatic frictional flow, Isothermal frictional flow (elementary treatment only). **Experiential Learning:** Study of finding co efficient of losses in straight pipes due to sudden enlargement, sudden contraction and bends. **Applications:** Frictional losses due to change in area and direction of pipes in various pipes and conduits can be studied. Frictional losses due to change in area and direction of pipes in various pipes and conduits can be studied. **Video Links/Any other special information(Papers):** https://www.youtube.com/watch?v=mflbEZ7kUpU		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Transportation and metering of fluids: Pipes, Fittings and valves, Flow measuring devices, venturi meter, orifice meter, rotameter and pitot tube. Elementary concept of target meter, vortex-shedding meters, turbine meters, positive displacement meters,		

magnetic meters, Coriolis meters and thermal meters, Flow through open channel-weirs and notches. Performance and Characteristics of pumps-positive displacement and centrifugal pumps, Fans, compressors, and blowers.

Experiential Learning: Determination of co efficient of discharge of Venturi meter, orifice meter and notches experimentally and graphically. Also working of single and multi-stage centrifugal pump.

Applications: Students will be able to analyze the variations in discharge in various meters and notches like rectangular and v notch also characteristics of centrifugal pump.

Video Links/Any other special information:

https://uta.pressbooks.pub/appliedfluidmechanics/chapter/experiment-10/

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

Flow of fluid past immersed bodies: Drag, drag coefficient, Pressure drop – Kozeny-Carman equation, Blake-Plummer, Ergun equation, Fluidization, conditions for fluidization, Minimum fluidization velocity, Pneumatic conveying, Industrial application of Fluidization. **Dimensional analysis: D**imensional homogeneity, Rayleigh's and Buckingham Π- methods, Significance of different dimensionless numbers.

Experiential Learning: Demonstration of flow past packed and Fluidized bed.

Applications: Dimensional analysis helps to find the relationship among various variable in any chemical, mechanical systems. Most chemical engineering system requires flow of fluid pat solid catalyst adsorbent absorbent etc. This learning will help to analyze flow of fluid over such systems.

Video Links/Any other special information:

https://www.youtube.com/watch?v=OdldY3RLw24

Course outcomes:

CO1	Apply the concepts of fluid statics and dynamics to measure pressure and differentiate various flow phenomena.
CO2	Derive the fundamental equations and apply to solve various fluid flow problems
CO3	Understand the various equations for incompressible and compressible fluids in conduits.
CO4	Demonstrate the knowledge of fluid flow principles in various types of flow measurements, transportation and metering of fluids using experimental

	techniques and applications to industry.
CO5	Develop functional relationships using dimensional analysis and similitude to solve technical problems also to analyze the flow past immersed bodies.

Text Books:	
1	McCabe, W. L., Smith, J. C., &Harriott, P. (1993). *Unit operations of chemical engineering* (Vol. 5, p. 154). New York: McGraw-hill.
2	Bansal, R. K. (2005). *A textbook of fluid mechanics*. Firewall Media.
Reference Books:	
1	Kumar, K. L. (1988). Engineering fluid mechanics 4th edn (New Delhi: Eurasia).
2	Coulson J.H. and Richardson J.F. (1998). Chemical Engineering Vol-I, 5thedn.
3	Badger W.L. and Banchero J.T. (1997). Introduction to Chemical Engineering. (Tata McGraw Hill, New York).
4	Web Link and Video Lectures: https://nptel.ac.in/courses/103104043/ https://cosmolearning.org/courses/fluid-mechanics-chemical-engineering/video-lectures/

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 (2 Nos.)		5X2=10
Assignments (2 Nos.)		5X2=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	2	--	--	--	--	--	--	--	--	--
CO2	3	3	3	--	--	--	--	--	--	--	--	--
CO3	3	3	3	--	--	--	--	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	1
CO5	3	3	3	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MECHANICAL OPERATIONS	Semester	III
Course Code	MVJ20CH34	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:

- Study different properties of particulate solids, handling and mixing of solid particles.
-

6AIV0sEWBR3eMAqREAAYASAAEgJgP_D_BwE		
Module-2	**RBT Level: L1, L2, L3**	**8 Hours**
Size Reduction: Introduction – types of forces used for comminution, Criteria for comminution, Characteristics of comminute products, Laws of size reduction, Work Index, Energy utilization, Methods of operating crushers – Free crushing, Choke feeding, Open circuit grinding, Closed circuit grinding, Wet and Dry grinding, Equipment for size reduction – Classification of size reduction equipment, Equipment – Blake jaw crusher, Gyratory crusher, Smooth roll crusher, Toothed roll crusher, Impactor, Ball mill, Critical speed of ball mill, Cutters – Knife cutter, Ultrafine grinder-Fluid energy mill, Colloid mill. **Experiential learning**: To determine the energy required for crushing the given feed and thus obtain the work index for the same. Also determine the reduction ration and critical speed of the mill and to determine the crushing law constants and verify the laws using jaw crusher. **Applications:**Ball mill and crushers are used in various industries like cement industry, mineral industry and ceramic industry for reducing the size of particles **Video Links/Any other special information(Papers):** https://www.youtube.com/watch?v=TlVxZlGiKyc https://www.youtube.com/watch?v=1CpjRMICXNM		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Filtration: Introduction, Classification of filtration, Cake filtration, Clarification, batch and continuous filtration, Pressure and vacuum filtration, Derivation of Constant rate filtration and Constant Pressure filtration, Characteristics of filter media, Industrial filters: Sand filter, Filter press, Leaf filter, Rotary drum filter, Principles of Centrifugal filtration, Rate of washing – Suspended batch centrifuge, Filter aids, Application of filter aids. **Experiential learning**: Demonstrate the working of a leaf filter and Plate & Frame filter. **Applications:** Filtration is used to separate particles and fluid in a suspension, where the fluid can be a liquid, a gas or a supercritical fluid. Filtration is major unit operation in edible oil manufacturing, water treatment etc **Video Links/Any other special information:** https://www.youtube.com/watch?v=lRBPQmectLQ http://uorepc-nitk.vlabs.ac.in/exp6/index.htmlv		

Module-4	RBT Level: L1, L2, L3	8 Hours
Motion of particles through fluids: Mechanics of particle motion, Equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal velocity, Motion of spherical particles in Stokes's region, Newton's region, and Intermediate region, Criterion for settling regime, Hindered settling, Modification of equation for hindered settling. **Sedimentation:** Batch settling test, Coe and Clevenger theory, Kynch theory, thickener design, Equipment: Gravity Settling Tank, Disk Bowl Centrifuge. **Experiential learning**: Batch sedimentation test, To determine the specific cake resistance and filter medium resistance, Rm by Filtration method **Video Links/Any other special information:** https://www.youtube.com/watch?v=M4wBd1_CvNw https://www.youtube.com/watch?v=gCJ3b8UM4EQ		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Agitation and mixing: Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and power calculation, mixing of solids, mixing index, Types of mixers –, Muller mixers, Mixing index, Ribbon blender, Internal screw mixer. **Sampling, storage and conveying of solids:** Sampling of solids, Storage of solids, Open and closed storage, Bulk and bin storage, Conveyors – Belt conveyers, Chain conveyor, Apron conveyor, Bucket conveyor, Screw conveyor. **Miscellaneous separation:** Centrifugal separators: Cyclones and Hydro cyclones, Magnetic separation, Electrostatic separation. **Experiential learning**: To separate the iron filings from the sand particles by performing froth floatation experiment. **Applications:** There are various industrial application of separation equipment i,e froth floatation, ESP, heavy media separator, magnetic separator which is discussed in this module. **Video Links/Any other special information(Papers):** https://www.youtube.com/watch?v=eu4T080dsG8 https://www.youtube.com/watch?v=nlfJt9rXWto		

Course outcomes:	
CO1	Study different properties of particulate solids, handling and mixing of solid particles.
CO2	Study principles of comminution and different types of equipment for size reduction like crushers, grinders etc.
CO3	Derive the expression to find rate of filtration for various types of filtration and to study the working of various filtration equipment's.
CO4	Explain the phenomenon of motion of particles through fluids in various flow fields and regimes, Outline the various theories of Sedimentation in designing industrial thickeners.
CO5	Explain various miscellaneous separation processes and also illustrates the working principle of agitation and mixing and describe the sampling of solid and conveying of it.

Text Books:	
1	McCabe, W. L., Smith, J. C., &Harriott, P. (1993). *Unit operations of chemical engineering* (Vol. 5, p. 154). New York: McGraw-hill.
2	Badger, W. L., &Banchero, J. L. (2010). Introduction to chemical engineering. 25th reprint.
Reference Books:	
1	McCoy, B. J. (1993). CHEMICAL ENGINEERING: Vol. 2. Particle Technology and Separation Processes, by JM Coulson, JF Richardson, JR Backhurst, and JH Harker. *Chemical Engineering Education*, *27*(3), 183-199.
2	Montillon, G. H. (1951). Unit Operations. By GG Brown, AS Foust, DL Katz, R. Schneidewind, RR White, WP Wood, JT Banchero, GM Brown, LE Brownell, JJ Martin, GB Williams, and JL York. *The Journal of Physical Chemistry*, *55*(4), 614-616.
3	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., & Andersen, L. B. (2008). *Principles of unit operations*. John Wiley & Sons.
4	**Web Link and Video Lectures:** https://nptel.ac.in/courses/103107123/ https://swayam.gov.in/nd1_noc19_ch32/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**
Assignments (5 Nos.)		**5X4=20**
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	2	--	--	--	--	--	--	--	--	--
CO2	3	3	2	--	--	--	--	--	--	--	--	--
CO3	3	3	2	--	--	--	--	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	--
CO5	3	3	1	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MATERIAL SCIENCE FOR CHEMICAL ENGINEERS	Semester	III
Course Code	MVJ20CH35	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 concepts on properties and selection of metals, ceramics, and polymers for design and Manufacturing.
-

Video Links: http://apniphysics.com/viva/ionization-experiment-physics/ https://vlab.amrita.edu/?sub=2&brch=190&sim=338&cnt=1		
Module-2	**RBT Level: L1, L2, L3**	**8 Hours**
Crystal Imperfection: Point Imperfections, Line imperfections – edge and screw dislocations, the Burgers vector, line energy of dislocations, Surface imperfections. **Basic thermodynamic functions:** phase diagrams and phase transformation: Single component systems, Binary phase diagrams, Lever rule, typical phase diagrams for Magnesia-Alumina, Copper – Zinc, iron – carbon systems, Nucleation and growth. Solidification, Allotropic transformation **Experiential Learning:** Heat treatment processes can be adopted to study the phase transformation **Applications:** Phase transformation can be adopted to predict the various crystal structure of metals **Video Links:** http://www.cittumkur.org/mech2019/MTLab.pdf		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Deformation of Materials and Fracture: Elastic deformation, Plastic deformation, Visco-elastic deformation, Stress and strain curve for ductile & brittle material, creep, Different types of fracture. **Heat Treatment**: Annealing, Normalizing Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Furnace types. **Experiential Learning:** (1) To determine Young's modulus of elasticity of the material of a given wire. (2) To study the heat treatment process (Annealing) Applications: (1) Young's modulus of elasticity defines the relationship between stress (force per unit area) and strain (proportional deformation) in a material. (2) Annealing reduces internal stress, softens the metal & improve the ductility of metals **Video Links:** https://byjus.com/physics/to-determine-youngs-modulus-of-elasticity-of-the-material-of-a-given-wire/ http://www.cittumkur.org/mech2019/MTLab.pdf		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**

Corrosion and its Prevention: corrosion and its manifestations, consequences, direct corrosion, Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factors influencing corrosion rate, control and prevention of corrosion-modification of corrosive environment, inhibitors, protective coatings, Specific types of corrosion.

Experiential Learning: Construction & working of galvanic cell

Applications: Galvanic cells and batteries are typically used as a source of electrical power.

Video Links:

https://www.uccs.edu/Documents/chemistry/nsf/106%20Expt9V-GalvanicCell.pdf

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

Typical engineering materials: Ferrous metals, non-ferrous metals and alloys, Aluminium and its alloys, Copper and its alloy, Lead and its alloy, Tin, Zinc and its alloy, silicon and its alloys, Alloys for high temperature service, Ceramic materials- structure of ceramics, polymorphism, Mechanical, electrical and thermal properties of ceramics phases, Refractories, Glasses, abrasives, plastics, fibres, and elastomers, Organic protective coating.

Experiential Learning: To determine the shear stress & hardness of engineering materials

Applications: To select the material of construction in automotive, structural, failure analysis, quality control, aerospace & other types of industries

Video Links:

http://www.cittumkur.org/mech2019/MTLab.pdf

Course outcomes:

CO1	Classify different types of engineering materials depending on structure property, crystal geometry and X-Ray diffraction, atomic structures, types of bonding.
CO2	Explain crystal imperfections and. Draw phase diagrams of different metals, TTT curves.
CO3	Enumerate deformation of materials and Suggest different type of heat treatment techniques depending on the type of the material.
CO4	Interpret different types of corrosions and suggest preventive methods
CO5	Select materials depending on type of application.

Text Books:

1	Raghavan, V. (2006). *Materials Science and Engineering: A First Course*, 468 s.
2	HajraChoudhury S.K. (1982). *Materials Science and Processes*. Indian book distributing Co.
Reference Books:	
1	Van Vlack H.L. (2002). *Elements of Material Science.* Addison – Wesly Publish Company, New York.
2	Chanda, M. (1981). *Science of Engineering Materials,* McMillan Company of India Ltd
3	**Web Link and Video Lectures:** https://nptel.ac.in/courses/113107078/ https://freevideolectures.com/course/2266/material-science

Scheme of Evaluation:

Details		**Marks**
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e., Σ (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 - 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	2	--	--	--	--	--	--	--	--	--	--
CO2	2	2	--	--	--	--	--	--	--	--	--	--
CO3	2	2	--	--	--	--	--	--	--	--	--	--
CO4	2	2	--	--	--	--	--	--	--	--	--	--
CO5	2	2	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	TECHNICAL CHEMISTRY	Semester	III
Course Code	MVJ20CH36	CIE	50
Total No. of Contact Hours	40 L : T : P :: 30 : 10 : 00	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3hrs

Course objective is to:

- To familiarize the students with the principles of some important topics in physical Chemistry, Inorganic Chemistry and Organic Chemistry.

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

Bonding: Atomic and Molecular orbital theory: Theory of bonding, Types of bonds, Hydrogen bond with discussion on interaction between two atoms such as exchange of electron, screen effect of electrons. Anti-bonding, Bond theory of metals, Theory of resonance, Structural stability, structure of carbonate ion and benzene, Importance of resonance compounds

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

Phase rule: Definition of terms, derivation and application of phase rule consisting of two component system.

Surface chemistry: Introduction, adsorption and absorption, types of adsorption, physical and chemical adsorption, adsorption isotherms, Freundlich, Langmuir and BET and applications of adsorption-industrial, general, analytical.

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

Isomerism: Definition, Types, Conformational isomerism in alkanes, free rotation about carbon- carbon single bond, conformation of ethane, propane n, butane, relative stability of different conformations. Optical isomers – Isomer number & tetrahedral carbon atom chirality, optical isomerism with one asymmetric carbon atom, Polarimeter, Specific rotation, Enantiomerism R & S Nomenclature. Geometrical isomerism – Definition, conditions for geometrical isomerism, cis-trans & E-Z nomenclature, physical & chemical properties of geometrical isomerism.

Coordination chemistry: Werner's theory, Nomenclature, properties effective atomic number, stability of complex ions, factors affecting the stability, Bonding in coordination compounds, Crystal field theory, stereochemistry of co-ordination compounds. Isomerism

of co-ordination compounds. Importance of coordination compounds.		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Heterocyclic compounds: Nomenclature, Classification, Structure, Preparation, Properties & Reactions of Heterocyclic, Analogues of Cyclopropane, Cyclo butane Cyclopentadiene, Heterocyclic's one or more hetero atoms, Azetidenes, Furans, Pyratidine, Pyroles, diazines, Fused heterocyclics, Heterocyclics in Dyes, Medicines, Natural products.		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Reactions & mechanisms: Concept of Steady states, reactive intermediates, Carbanions, Carbocations, Inductive and resonance effects. Mechanism of nucleophilic substitution (SN1 and SN2) in alkyl halides. Mechanism of elimination reactions (E1 and E2). Mechanism of electrophilic substitution in benzene, nitration, sulphonation, halogenation. Friedel-crafts alkyl and acylation reactions. Electronic interpretation of orienting influence of substituents in aromatic electrophilic of toluene, chlorobenzene, phenol, Benzonitrile, aniline and nitrobenzene. Solvents effects.		
Laboratory Sessions		

Activity:

1. Model making of Different geometrical isomers.
2. Preparation of adsorbents for the treatment of colored waste water.

Break up of CIE marks: CIE: 50

(i) **Average of three internal Assessment (IA) Tests** :30

(ii)

At least Three **Bibliography** and **Two webliography** are to be included in each assignment by the students.

(a) Innovative Activity: 10 marks:

Allocation of marks for Innovative Activity:

Relevance of the topic	2 marks
Print Preview / Presentation (seminar)	5 marks
References **Bibliography / webliography**	3 marks

This innovative work can be taken by a 4 set of students. Innovative work should be related to their respective syllabus. **SEE: 50**

Course outcomes:

On successful completion of this course students will be able to

CO1	Explain the bond theory Resonance theory H-O-H Bonds
CO2	Understand the techniques of Surface chemistry and phase rule and their application in industry.
CO3	Explain the structure and bonding of coordination compounds with proper reason of deviation, isomerism prevailing
CO4	Write reaction mechanisms in various types of reactions.

Text Books:

1.	Puri L.R. and Sharma B.R., **"Physical Chemistry"**, 14th edn., Chand S. and Company, New Delhi, 1998.

Reference Books:

1.	James Huheey, **"Inorganic Chemistry"**, 19thedn. Wiley Publishers, New Delhi, 1997.
2.	Dhone D. B., A Text Book of Plant Utilities, Nirali Publications.

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	MOMENTUM TRANSFER LAB	Semester	III
Course Code	MVJ20CHL37	CIE	50
Total No. of Contact Hours	20 L:T:P::0:10:10	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to:

- This course aims to familiarize students with the principles of Fluid mechanics.

S. No.	Experiment Name	RBT Level	Hours
1.	Friction in circular pipes.	L1, L2, L3	3
2.	Friction in non-circular pipes.	L1, L2, L3	3
3.	Friction in helical/spiral coils.	L1, L2, L3	3
4.	Flow measurement using venturi (incompressible fluid).	L1, L2, L3	3
5.	Flow measurement using orifice meters (incompressible fluid).	L1, L2, L3	3
6.	Flow over notches- find the coefficient of discharge through various notches.	L1, L2, L3	3
7.	Flow through open orifice-Hydraulic coefficients.	L1, L2, L3	3
8.	Flow through Packed bed-Verify ERGUN'S Equation	L1, L2, L3	3
9.	Flow through Fluidized bed- to calculate the minimum fluidization velocity	L1, L2, L3	3
10	Study of characteristics for centrifugal, Positive displacement pump	L1, L2, L3	3
11.	Study of various pipe fittings and their equivalent lengths.	L1, L2, L3	3
12.	Unsteady flows - Emptying of Tank	L1, L2, L3	3

Course outcomes:

CO1	Identify, name, and characterize flow patterns and regimes.
CO2	Measure fluid pressure and relate it to flow velocity.
CO3	Demonstrate practical understanding of friction losses, coefficient of discharge in various notches and pipes.
CO4	Explain fluid flow in channels and application of flow meters and notches.

CO5	Study of characteristics & efficiency of centrifugal, Positive displacement pump

Scheme of Evaluation:

Details		Marks
Regular lab work	CIE (50)	30
Record writing		10
Viva-voce		10
Semester End Examinations	SEE (50)	20
	Total	100

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

High-3, Medium-2, Low-1

Course Title	TECHNICAL CHEMISTRY LAB	Semester	III
Course Code	MVJ20CHL38	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	3hrs
Course objective is to: This course aims to familiarize students with the principles of technical chemistry and basic analytical techniques including volumetric analysis.			
Laboratory Experiments:			
1. Critical Solution Temperature-Water–Phenol System. 2.			

	and molecular weight of chemical components.
CO4	Predicttheorganicreactionmechanismandtoestimatefunctionalgroupsemploying differenttechniques.
CO5	Have knowledge of handling instruments for precise analysis.

CIE: 50

SEE:50

Reference Books:	
1.	ESSENTIALS OF EXPERIMENTAL ENGINEERING CHEMISTRY by SHASHICHAWLA, DHANPATRAI PUBLICATIONS.
2.	VOGEL'S QUANTITATIVE CHEMICAL ANALYSIS by J. MENDHAM,R.C. DENNEY, J.D.BARNES, M.J.K.THOMAS,PEARSON.

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

High-3, Medium-2, Low-1

Course Title	SAMSKRUTHIKA KANNADA	Semester	III
Course Code	MVJ20SK39	CIE	50
Total No. of Contact Hours	20 L: T: P 20:0:0	SEE	50
No. of Contact Hours/week	1	Total	100
Credits	1	Exam. Duration	3Hrs

Course objective:

- Samskruthika Kannada –Parichaya (Introduction to Adalithakannada)
-

ಅಧ್ಯಾಯ –೧೦		
ಪಾರಿಭಾಷಿಕ ಆಡಳಿತ ಕನ್ನಡ ಪದಗಳು ಮತ್ತುತಾಂತ್ರಿಕ/ಕಂಪ್ಯೂಟರ್ ಪಾರಿಭಾಷಿಕ ಪದಗಳು.		
Scheme of Evaluation:		
Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e.Σ (Marks Obtained in each test) / 3	CIE(50)	30
ASSIGNMENT		20
Semester End Examination	SEE (50)	50
	Total	100

Course Title	BALIKE KANNADA	Semester	III
Course Code	MVJ20BK39	CIE	50
Total No. of Contact Hours	14	SEE	50
No. of Contact Hours/week	1 Hour/week	Total	100
Credits	1	Exam. Duration	Hours

Course objective is to: The course will enable,

- The students to understand Kannada and communicate in Kannada language.
-

Samay/KalakkeSambhandhisidapadagalu (Words Relating to Time) ,Dikkugaligesambhasidhisidapadagalu (words Related to Directions),ManushyanaBhavanegaligesambhadhisidaPadagalu (Words Related to Humen's Feelings and Emotions),Manushyanashareeradabhagagalu (Parts of the Human Body),Sambhandhisidasambhandhakkepadagalu (Words Related to Relationship), Vasadstalakkesambhandhisidapadagalu (Words Related to Place of Living), SaamanyaSambhasaneyallibhalasuvanthaPadagala Patti (List of Words used in the general communication) & Colors in Kannada **Experiential Learning:** 1.Based on the above topics Exercises **Video Links**: https://youtu.be/PoQ9m16d7QA		
Module-4	**L1&L2**	**8 Hours**
Kannada Grammer in Conversations (Sambhasaneyalli Kannada Vyakarna):Introduction , Nouns (Naampadagalu), Pronoun (Sarvanaampadagalu) , Use of Pronouns in Kannada Sentences , Adjectives (Kannada namaVishenegalu) , Kannada Verbs (Kriya Padagalu) , Adverbs in Kannada (Kriya Vishenegalu) , Conjuctions in Kannada (Sanyaga) , Preposition in Kannada (Poorvabhavi). **Experiential Learning:** Questions constructing words in Kannada (PrashnarthakaPadagalu), Simple Communicative Sentences in Kannada, Exercise for Practice, Enquiry Questions **Video Links:** https://youtu.be/fd966GC8Yko		
Module-5	**L1 &L2**	**1Hour**
Activies in Kannada (KannadadalliChatuvatikegalu): Activites –Vocubulry (Shabdakosh), Conversation (Shambhasane) **Experiential Learning:** Try to communicate with each other in Kannada **Video Links:** https://youtu.be/fd966GC8Yko		
Course outcomes:		
CO1	Understanding the advantage of learning a local language	
CO2	Understanding the difference between pronunciation of English and Kannada	
CO3	Understanding the word meaning in Kannada and frame the simple sentences if any difficulty can use any other language words to complete the conversation	
CO4	Understanding the word meaning and frame the sentences and try to translate Kannada to English vise versa	

CO5	Understanding the Kannada grammar and how to implement in Kannada sentences for communication

Text Books:	
1	Sankispta Kannada Nighantu (Parishkratha), Kannada sahitya Parishatha,Bangalore
2	Mysore vishwavidyalayada English –Kannada Nighantu (Parishkratha) samputa –(A inda Z varage)
3	Kacheri Kaipidi –Dr .Ha .Ma. Nayak, Kannada Adhyanasamsthe . Mysorevishwavidyalayada ,1974
Reference Books:	
1.	Vyavharika Kannada PatyaPusthaka by L.Thimmesha

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

iv. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

v.

Course Title	CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW	Semester	III
Course Code	MVJ20CPH39	CIE	50
Total No. of Contact Hours	20 L : T : P :: 20:0 : 0	SEE	50
No. of Contact Hours/week	01	Total	100
Credits	01	Exam. Duration	2 hrs

Course objective is to:

- To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.
-

Elections, Amendments and Emergency Provisions: Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements). Emergency Provisions, types of Emergencies and it's consequences. **Constitutional Special Provisions:** Special Constitutional Provisions for SC & ST, OBC, Special Provision for Women, Children & Backward Classes.		
Module – 4	**RBT Level: L1, L2, L3**	**4 Hours**
Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India): Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. **Responsibilities in Engineering -** Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.		
Module – 5	**RBT Level: L1, L2, L3**	**4 Hours**
Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.		

Scheme of valuation:

Details		
Average of three Internal Assessment (IA) tests of 40 Marks each i.e., Σ(Marks obtained in each test)/3	**CIE (50)**	**40**
Assignment		**10**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Course Outcomes: On completion of this course, students will be able to

CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.

CO3	Understand the cyber crimes and cyber laws for cyber safety measure.

Text Books:	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
Reference Books:	
1.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.)Prentice –Hall EEE, 19th/20thEdn., (Latest Edition) or 2008.
2.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.
3	M.Govindarajan, S.Natarajan, V.S.Senthilkumar, "Engineering Ethics", Prentice –Hall of India Pvt. Ltd. New Delhi, 2004.
4.	M.V.Pylee, "An Introduction to Constitution of India", Vikas Publishing, 2002.
5.	Latest Publications of NHRC - Indian Institute of Human Rights, New Delhi.

Course Title	ADDITIONAL MATHEMATICS-I (COMMON TO ALL BRANCHES)	Semester	III
Course Code	MVJ20MATDIP31	CIE	50
Total No. of Contact Hours	40 L:T:P 30:10:00	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	-	Exam. Duration	3hrs

Course objective is to: This course viz., aims to prepare the students:

To familiarize the important and basic concepts of Differential calculus and Differential Equation, ordinary/partial differential equations and Vector calculus and analyse the engineering problems.

Module-1	RBT Level: L1, L2	8 Hours

Differential calculus: Recapitulations of successive differentiations -n^{th} derivative - Leibnitz theorem and Problems, Mean value theorem -Rolle's theorem, Lagrange's Mean value theorem , Cauchy's theorem and Taylor's theorem for function of one variables.

Video Link:

https://users.math.msu.edu/users/gnagy/teaching/ode.pdf

Module-2	RBT Level: L1, L2	8 Hours

Integral Calculus: Review of elementary Integral calculus, Reduction formula $\int_0^{\frac{\pi}{2}} sin^m x\, dx$, $\int_0^{\frac{\pi}{2}} cos^m x\, dx$, $\int_0^{\frac{\pi}{2}} sin^m cos^n x\, dx$ and problems. Evaluation of double and triple integrals and Simples Problems.

Video Link:

https://www.youtube.com/watch?v=rCWOdfQ3cwQ

https://nptel.ac.in/courses/111/105/111105122/

Module-3	RBT Level: L1, L2	8 Hours

Vector Calculus: Derivative of vector valued functions, Velocity, Acceleration and related problems, Scalar and Vector point functions, Gradient, Divergence, Curl, Solenoidal and Irrotational vector fields. Vector identities - div (φA), curl (φA), curl (grad φ), div (curl A).

Video Link:

https://www.whitman.edu/mathematics/calculus_online/chapter16.html

https://www.math.ust.hk/~machas/vector-calculus-for-engineers.pdf		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Probability: Introduction-Conditional Probability, Multiplication theorem, Independent events, Baye's theorem and Problems. **Video Link:** https://www.khanacademy.org/math/statistics-probability/probability-library https://nptel.ac.in/courses/111/105/111105041/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Differential equation: Homogenous differential equation, Linear differential equation, Bernoulli's differential equation and Exact differential equation. Video Link: https://www.mathsisfun.com/calculus/differential-equations.html		

Course outcomes:	
CO1	Apply the knowledge of Differential calculus in the modeling of various physical and engineering phenomena
CO2	Apply the concept of change of order of integration and variables to evaluate multiple integrals and their usage in computing the area and volumes.
CO3	Study on Vector calculus to understand the various solution to Application to Engineering problems.
CO4	Understand the basic Concepts of Probability
CO5	Solve first order linear differential equation analytically using standard methods.

Text Books:	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition 2013.
2.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
Reference Books:	
1	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers,

	10thedition,2014.
2	G. B. Gururajachar: Calculus and Linear Algebra, Academic Excellent Series Publication, 2018-19

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (10 marks)
- Assignment (10 marks)

SEE Assessment:

vii. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

viii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

ix. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	3	0	0	0	0	0	0	1	1
CO2	2	3	0	3	0	0	0	0	0	0	1	1
CO3	2	2	0	2	0	0	0	0	0	0	1	0
CO4	3	2	0	3	0	0	0	0	0	0	0	1
CO5	3	3	0	2	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	UNIVERSAL HUMAN VALUES I	Semester	III
Course Code	MVJ20UHV310	CIE	50
Total No. of Contact Hours	15 L: T : P :15 : 0 :0	SEE	50
No. of Contact Hours/week	1	Total	100
Credits	1	Exam. Duration	3 Hrs.

Course objective is to: This course will enable the students to

- Perceive the need for developing a holistic perspective of life
-

- https://www.youtube.com/watch?v=E1STJoXCXUU&list=PLWDeKF97v9SP_Kt6jqzA3pZ3yA7g_OAQz
- https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Module-3	RBT Level: L1, L2	3 Hours

Introduction to Harmony in the Human Being: Understanding Human being as the Co-existence of the Self and the Body, The Body as an Instrument of the Self, Harmony of the Self with the Body.

Video link:

- https://www.youtube.com/watch?v=GpuZo495F24
-

Scheme of Evaluation

Details		Marks
Assessment by Faculty mentor (Class Room Evaluation)	CIE(50)	10
Self-Assessment + Assessment by peers		20
Activities / Experimentations related to courses/Assignment		10
Mini Projects / Case Studies		10
Semester End Examination	SEE (50)	50
	Total	100

Text Books:

1.	AICTE SIP UHV-I Teaching Material, https://fdp-si.aicte india.org/ AicteSipUHV _download.php
2.	A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1
3.	Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

Reference Books:

1.	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010
2.	Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3.	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4.	The Story of Stuff (Book).
5.	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	**COMPLEX ANALYSIS, PROBABILITY AND SAMPLING THEORY**	**Semester**	IV
Course Code	MVJ20MCH41	**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:

The purpose of this course is to make students well conversant with numerical methods to solve ordinary differential equations, complex analysis, sampling theory and joint probability distribution and stochastic processes arising in science and engineering.

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

Complex Variables-I: Review of a function of a complex variable, limits, continuity, and differentiability. Analytic functions-Cauchy-Riemann equations in Cartesian and polar forms. Properties and construction of analytic functions. Complex line integrals-Cauchy's theorem and Cauchy's integral theorem. Conformal transformations-Discussion of transformations: $w=z^2$, $w=e^z$, $w=z+(1\ z)(z\neq 0)$.

Applications: It is useful in many branches of mathematics, including algebraic geometry, applied mathematics; including the branches of hydrodynamics, thermodynamics, and particularly quantum mechanics.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=oiK4gTgncww

https://www.youtube.com/watch?v=WJOf4PfoHow

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

Statistical Methods: Introduction, Correlation and coefficient of co relation, Regression, line of regression problems. **Curve Fitting:** Curve fitting by the method of least squares-fitting of the curves of the form, $y = ax + b$, $y = ax^2 + bx + c$ and $y = ae^{bx}$.

Applications: Correlation and Regression is used to see whether two variables are associated, without necessarily inferring a cause-and-effect relationship. Another important application is to estimate the value of one variable corresponding to a particular value of the other variable. Curve Fittings such as parabola and hyperbola are used in architecture to design arches in buildings.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=xTpHD5WLuoA

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

https://www.youtube.com/watch?v=tl5QNhSe0Yk

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

Probability Distributions: Random variables (discrete and continuous), probability mass/density functions. Binomial distribution, Poisson distribution. Exponential and normal distributions, problems.

Applications: Few of the application areas include in industries, quality control, in errors correction, medicine, agriculture, engineering, for analysis and interpretations of basic data obtained from experiments.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=nrkd0IlVxkY

https://www.youtube.com/watch?v=6x1pL9Yov1k

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

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation, covariance. **Stochastic Process:** Probability vector, Stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability – problems.

Applications: Stochastic processes are widely used as mathematical models of systems and phenomena that appear to vary in a random manner.

Video link / Additional online information (related to module if any):

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

https://www.youtube.com/watch?v=FWe5uk5NA5I

https://www.youtube.com/watch?v=4RnVwa9TG2g

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

Sampling Theory and Statistical Inference: Sampling, Sampling Distributions, Type I and Type II errors, standard error, Z – test, student's t- distribution, test of hypothesis for means, test for hypothesis for proportions, confidence limits for means, Chi-square distribution as a test of goodness of fit.

Applications: A large number of analyses for process control, product quality control for consumer safety, and environmental control purposes are using Sampling Theory.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=zmyh7nCjmsg

https://www.youtube.com/watch?v=fuBvQJP0ecw&list=PLp6ek2hDcoNCp9o8aLQrbY15a-

o0weoTd&index=2 https://www.youtube.com/watch?v=tFRXsngz4UQ https://www.youtube.com/watch?v=Q1yu6TQZ79w	
Course outcomes:	
CO1	State and prove Cauchy - Riemann equation with its consequences and demonstrate Con-formal Transformation.
CO2	Illustrate Complex Integration using Cauchy's Integral theorem, Cauchy's Integral formula and Cauchy's Residue theorem.
CO3	Use Method of Least Square for appropriate Curves. And Fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data.
CO4	Develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, information theory and design engineering
CO5	Demonstrate testing of hypothesis of sampling distributions and illustrate examples related to discrete parameters.

Text Books:	
1	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition 2013.
2	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10thedition,2014.
Reference Books:	
1	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
2	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition
3	Jain R. K.& IyengarS.R.K., Advanced Engineering Mathematics, Narosa Publishing House, 2002.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (10 marks)

- Assignments (10 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	CHEICAL ENGINEERING THERMO DYNAMICS	Semester	IV
Course Code	MVJ20CH42	CIE	50
Total No. of Contact Hours	50 L:T:P::30:20:0	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- Learn fundamentals of thermodynamics such as types of properties, processes and laws of thermodynamics for flow and non-flow process.
-

Video Links/Any other special information: https://nptel.ac.in/courses/103101004/		
Module-2	**RBT Level: L1, L2, L3**	**10 Hours**
P-V-T Behaviour: P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes. Equation of state for real gases: Vander Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation, Compressibility charts: Principles of corresponding states, generalized compressibility charts. **Second Law of Thermodynamics:** General statements of the Second law, Concept of Entropy, The Carnot Principle, calculation of entropy changes, Clausius Inequality, Entropy and Irreversibility, Third law of Thermodynamics. **Experiential learning:** (Experiments which can be conducted on the concepts of contents) Explain the concept of entropy with simple reaction **Applications:** Application of first law and second law of thermodynamics for fluid flow problems. Estimation the behaviour of real fluids using various equation of state and degree of randomness. **Video Links/Any other special information:** https://www.cpalms.org/Public/PreviewResourceLesson/Preview/75658		
Module-3	**RBT Level: L1, L2, L3**	**10 Hours**
Thermodynamic Properties of Pure Fluids: Reference Properties, Energy Properties, Derived Properties, Work function, Gibbs free energy, Relationships among thermodynamic properties, Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for U & H, Effect of temperature on U, H & S, Relationships between CP & CV, Gibbs- Helmholtz equation, Fugacity, Fugacity coefficient, Effect of temperature and pressure on Fugacity, Determination of Fugacity of pure gases, Fugacity of solids and liquids, Activity, Effect of temperature and pressure on activity. **Applications:** Evaluation of the thermodynamic properties of pure fluids using measurable quantities like the pressure-Volume temperature relationship. **Video Links/Any other special information:** https://nptel.ac.in/content/storage2/courses/103101004/downloads/chapter-5.pdf		
Module-4	**RBT Level: L1, L2, L3**	**10 Hours**
Properties Of Solutions: Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, activity in solutions, Activity coefficients, Property changes of mixing, excess properties.		

Experiential learning: Determination of partial molar volume for different compositions of ethanol –water system.

Applications: Partial molar properties are useful because chemical mixtures are often maintained at constant temperature and pressure and under these conditions, the value of any extensive property can be obtained from its partial molar property. They are especially useful when considering specific properties of pure substances (that is, properties of one mole of pure substance) and properties of mixing (such as the heat of mixing or entropy of mixing)

Video Links/Any other special information (Papers):

https://www.youtube.com/watch?v=FLRkGbzw0-

Module-5	RBT Level: L1, L2, L3	10 Hours

Phase Equilibria: Criteria of phase Equilibria, Criterion of stability, Duhem's theorem, Vapor – Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, consistency test for VLE data, Calculation of Activity coefficients using Gibbs – Duhem's equation.

Experiential learning: To generate VLE data for a binary mixture of Acetone and Benzene.

Applications: Thermodynamics of chemical reactions predicts the equilibrium conversion attainable in a chemical reaction and the effect of operating conditions on the degree of completion of the reaction.

Video Links/Any other special information:

https://www.chem.uci.edu/~lawm/263%206.pdf

Course outcomes:

CO1	Calculate the heat and work requirements for the given flow or non-flow processes.
CO2	Analyse and find properties such as Pressure, Volume and temperature for equations of states and from the fundamentals of first law of thermodynamics.
CO3	Calculate entropy for the processes, and various types of energies such as internal energy, enthalpy, Helmholtz free energy and Gibbs free energy.
CO4	Differentiate between ideal and non-ideal solution and estimate partial molar properties.
CO5	Identify the role of thermodynamics in the design and operation of chemical reaction system.

Text Books:	
1	Smith, J. M., Van Ness, H. C., & Abbott, M. M. (1987). Introduction to Chemical Engineering Thermodynamics McGraw Hill. *Inc.: New York*.
2	Rao, Y. V. C. (1997). *Chemical engineering thermodynamics*. Universities Press.
Reference Books:	
1	Narayanan, K. V. (2004). *A textbook of chemical engineering thermodynamics*. PHI Learning Pvt. Ltd..
2	**Web Link and Video Lectures:** https://nptel.ac.in/courses/103101004/

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
Assignments		10
Seminar		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	3	3	--	--	--	--	--	--	--	--	--
CO2	2	3	3	2	--	--	--	--	--	--	--	--
CO3	2	3	3	2	--	--	--	--	--	--	--	--
CO4	2	3	3	--	--	--	--	--	--	--	--	--
CO5	2	3	3	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	CHEMICAL REACTION ENGINEERING-1	Semester	IV
Course Code	MVJ20CH43	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 the scope of Chemical reaction Engineering.
-

http://encyclopedia.che.engin.umich.edu/Pages/Reactors/PBR/PBR.html

https://www.youtube.com/watch?v=AzK7K601cAE

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

Design of reactors: Design of Batch, Semi-batch, laminar and mixed flow ideal reactors and their performance equations. Constant volume and variable volume reactors. Design of batch reactor, PFR and MFR. Space time and space velocity, Holding time for flow reactors. Size comparison of ideal reactors. Numerical problems.

Experiential Learning: Virtual demonstration of reaction kinetic studies in batch reactor, PFR and MFR.

Applications: Design of industrial reactors.

Video Links/Any other special information:

http://uorepc-nitk.vlabs.ac.in/#

https://www.youtube.com/watch?v=ftnLJ6VDwS8

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

Multiple Reactor Systems: Plug flow and /or Mixed flow reactors in Series, parallel and series-parallel. Reactors of different types and sizes in series. Design of Reactors for Multiple Reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel, Series and Series- Parallel reactions (Only irreversible reactions must be considered).

Experiential Learning: PFR and MFR in series operation.

Applications: Working and designing of multiple reactor system

Video Links/Any other special information:

https://www.youtube.com/watch?v=puJXBMtB4W4

https://www.youtube.com/watch?v=SVfs9JzMYoc

https://www.youtube.com/watch?v=TleC05u13fI

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

CHEMICAL REACTION EQUILIBRIUM: Reaction Stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, Pressure on equilibrium constants and other factors affecting equilibrium conversion, Liquid phase reactions, heterogeneous reaction equilibrium, phase rule for reacting systems. **Non-Isothermal Reactors**: Introduction, effect of temperature on equilibrium constant and heat of reaction, Material and Energy balances, conversions in adiabatic and non-adiabatic reactors. **Analysis of Non-Isothermal Reactor**: Design procedure for single reactions, Optimum temperature Progression, Safety concepts for non-isothermal reactors. Numerical problems.

Experiential Learning: To analyze the conversion in an adiabatic reactor. **Applications:** Equilibrium studies on reactive processes help to understand the feasibility and maximum possible yield of the desired product at any given conditions. Non-isothermal reactor systems studies will help to design a reactor and predict conversions under non-isothermal conditions. **Video Links/Any other special information**: https://www.youtube.com/watch?v=WCbnTMBo4Co	
Course outcomes:	
CO1	Explain various types of reactions, factors affecting rate equation, theories for predicting temperature dependency of rate constant and kinetics.
CO2	Interpret experimental data using differential, integral, and half-life methods, and types of chemical reactors with real practise.
CO3	Develop design equations for ideal reactors for constant and variable volume reactions and generating kinetic data in ideal reactors.
CO4	Develop the design of single and multiple reactor systems and reactions.
CO5	Design non isothermal reactors and discuss optimum temperature progression.
Text Books:	
1	Octave Levenspiel. (2004). Chemical Reaction Engineering 3rd edn. ISBN 9780471254.
2	Smith, J. M. (1981). *Chemical engineering kinetics* (No. TP149 S58).
Reference Books:	
1	Fogler, H. S. (2010). *Essentials of Chemical Reaction Engineering: EssentiChemicaReactioEngi*. Pearson Education.
2	**Web Link and Video Lectures:** https://nptel.ac.in/courses/103106116/ http://umich.edu/~elements/5e/lectures/index.html

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
Journals/Progress notes		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	2	3	1	--	--	--	--	--	--	--	--
CO2	3	2	3	1	--	--	--	--	--	--	--	--
CO3	3	3	3	1	--	--	--	--	--	--	--	--
CO4	3	3	3	2	--	--	--	--	--	--	--	--
CO5	3	3	3	2	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	CHEMICAL TECHNOLOGY	Semester	IV
Course Code	MVJ20CH44	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 Hours

Course objective is to:

- · Understand the basic concepts of Industrial Processes practiced in different Inorganic & Organic Chemical Industries.
-

fermentation technology.

Applications:

Production of alcohol, extraction of vegetable oil and chemical processes associated with it can be studied.

Video link / Additional online information:

https://www.youtube.com/watch?v=lcXnWrDZV6Q

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

Chlor-alkali and cement industries: Sodium chloride, Soda ash, Caustic soda, Chlorine. **Cement industries**: Classification, manufacture, reactions, flow diagrams, major and minor engineering problems, applications.

Experiential learning:

To determine the energy required for crushing the sample and working of Ball mills and jaw crushers. Also determine the reduction ration and critical speed of the mill

Applications:

Ball mill and crushers are used in Cement industries for reducing the size of particles.

Video link / Additional online information:

https://www.youtube.com/watch?v=dAD03D5cTF8

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

Petroleum industries and petrochemicals: Origin and classification. Petroleum refining and processing Coal: Formation and Classification of coal, mining of coal, destructive distillation of coal, coking of coal, coal tar distillation, chemicals from coal. **Pulp and Paper Industries:** Raw materials, manufacture of pulp, paper and its major engineering problems.

Experiential learning: Demonstration of various unit operations and processes in production plants.

Applications: Basic concepts of unit operations and processes can be understood which finds applications in treatment and production of paper in industries.

Video link / Additional online information:

https://www.youtube.com/watch?V=e4c3x26dxbm

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

Inorganic fertilizers: Ammonia, urea, ammonium phosphate, ammonium nitrate, ammonium sulphate, DAP, phosphorous pentoxide, super phosphate and triple super phosphate. **Polymers & Rubber:** Macromolecules. Polymerization. PVC, LDPE. Polypropylene. Natural rubber.

Experiential learning: Exhibit the polymerization reactions by conducting experiment with simple monomers. **Applications:** Various types of polymerization can be studied for production of polymers. **Video link / Additional online information:** https://www.youtube.com/watch?v=JIV4ZX1Uh_4	
Course outcomes:	
CO1	Explain the basic processes for manufacture of industrial gases, acids, Soaps and Detergents also sources, impurities and treatment methods of water.
CO2	Get insight of cement manufacture, fermentation products and basic concepts of industrial processes practiced in the manufacture of Oils, Fats, and Waxes.
CO3	Outline the manufacture of Chlor-alkali and Cement industries
CO4	Explain the refining of petroleum, formation, classification of coal, destructive distillation of coal and manufacture of pulp and paper.
CO5	Learn industrial scale operations and processes employed in manufacture of fertilizers & polymers and rubber.

Text Books:	
1	Dryden – Outlines of Chemical Technology for 21st Century, Gopal Rao & Marshall Sittig, 3rd edn. EWP.
2	Shreve's Chemical Process Industries, 4th edn, McGraw Hill.
Reference Books:	
1	Unit Processes in Organic Chemical Industries, Desikan and Sivakumar (Eds.), CEDC, IITM, 1982.
2	Encyclopedia of Chemical Technology, Kirk and Othmer, 27th volume, 5th edn, Wiley, 2004.
3	Web Link and Video Lectures: https://swayam.gov.in/nd1_noc19_ch19/preview https://swayam.gov.in/nd1_noc19_cy20/preview https://nptel.ac.in/courses/103107082/ https://nptel.ac.in/courses/103103029/

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	1	--	--	--	--	--	--	--	--	--	1
CO2	2	1	--	--	--	--	--	--	--	--	--	1
CO3	2	1	--	--	--	--	--	--	--	--	--	--
CO4	2	1	--	--	--	--	--	--	--	--	--	--
CO5	2	1	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PROCESS HEAT TRANSFER	Semester	IV
Course Code	MVJ20CH45	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:

- Study various modes of Heat transfer and their fundamental relations.
-

Numerical Problems.

Convection: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor, Dimensionless numbers, Dimensional analysis, Empirical correlation for forced and natural convection, Analogy between momentum and heat transfer-Reynold, Colbourn, Prandtl analogies. Numerical Problems.

Experiential learning: Study the heat transfer in extended (finned) tube under natural convection using the experimental set up in heat transfer lab

Applications: Fins are widely used in many applications such as heating, ventilation and air conditioning system, finned tube heat exchangers, solar systems and electrical systems

Video Links/Any other special information:

https://www.youtube.com/watch?v=SNnd0f3xXlg

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

Heat Transfer with Phase Change: Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapours, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling, Numerical Problems.

Experiential learning: An experiment to determine the convective heat transfer coefficient in condensation process.

Applications: All chemical industries, thermal and nuclear power generation in steam plants, refrigeration, refining, heat transmission, etc

Video Links/Any other special information:

https://www.youtube.com/watch?v=j-TXp789inU

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

Radiation: Properties and definitions, Emissive power and intensity of radiation, Black body radiation, Grey body radiation, Stefan – Boltzmann law, Wein's displacement law, Kirchhoff's law, radiation shape factor, radiation between large parallel plates, Numerical Problems.

Experiential learning: Demonstrate how to determine the emissivity of a given grey body.

Applications: Emissivity is important in solar heat collectors, thermal shielding pyrometers and insulated windows.

Video Links/Any other special information:

https://www.youtube.com/watch?v=pbCf4507QvM		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Heat Transfer Equipment: Double pipe heat exchanger. Shell and tube heat exchangers, Condensers, Construction and working, Types of shell and tube heat exchangers, type of condensers. **Design of Heat Transfer Equipment:** Elementary design of double pipe heat exchanger. Shell and tube heat exchanger and condensers, Numerical Problems. **Evaporation:** Single and multiple effect operation, material and energy balance in evaporators, forward and backward feeds, capacity and economy of evaporators, Multiple effect evaporator – Methods of feeding. **Experiential learning: E**xhibit the working of heat exchangers, condensers, evaporators and boilers to get the complete understanding of the constructional details. **Applications**: They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. **Video Links/Any other special information:** https://www.youtube.com/watch?v=r67f4V6pOOw		

Course outcomes:	
CO1	Develop flux equations for steady state heat conduction and critical thickness of insulation in different geometry of solids.
CO2	Explain the types of fins, fin effectiveness and apply various correlations of convective heat transfer to different problems
CO3	Derive the Nusselt equation for heat transfer with phase change.
CO4	Interpret the phenomenon of radiation in different types of solids.
CO5	Develop the elementary design equations for various Heat exchangers

Text Books:	
1	McCabe, W. L., Smith, J. C., &Harriott, P. (1993). *Unit operations of chemical engineering* (Vol. 5, p. 154). New York: McGraw-hill.
2	Rao, Y. V. (2002).*Heat Transfer*. Universities Press.
Reference Books:	
1	Park, C. W. (1993). CHEMICAL ENGINEERING: Vol. 1. Fluid Flow, Hea t Transfer and Mass Transfer by JM Coulson and JF Richardson, with JR Backhurst and JH

	Harker. *Chemical Engineering Education*, *27*(3), 182-183.
2	Dutta, B. K. (2000). *Heat transfer: principles and applications*. PHI Learning Pvt. Ltd..
3	**Web Link and Video Lectures:** https://nptel.ac.in/courses/103103032/

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**
Assignments (3 Nos.)		**10**
Self Assesment Test		**6**
Polling/Comprehensive questions		**4**
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	3	0	0	0	0	0	0	0	0	0
CO2	2	3	3	2	0	0	0	0	0	0	0	0
CO3	2	3	3	2	0	0	0	0	0	0	0	0
CO4	2	3	3	0	0	0	0	0	0	0	0	0
CO5	2	3	3	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	INSTRUMENTAL ANALYSIS	Semester	IV
Course Code	MVJ20CH46	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	03	Exam. Duration	3 hrs

Course objective is to:

The course is designed to impart the knowledge in the field of Instrumental Analysis. The various modern analytical techniques like UV-Visible, IR, NMR, Mass, GC, HPLC, different chromatographic methods and other important topics are taught to enable the students to understand and apply the principles involved in the determination of different bulk drugs and their formulation. In addition to the theoretical aspects, the basic practical knowledge relevant to the analysis is also imparted.

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

Chromatography: Introduction, classification of chromatographic methods based on the mechanism of separation. Column Chromatography: Adsorption and partition, theory, preparation, procedure and methods of detection. Thin Layer Chromatography: Theory, preparation, procedures, detection of compounds. Paper Chromatography: Theory, different techniques employed, filter papers used, qualitative and quantitative detection. Counter – current extraction, solid phase extraction techniques, gel filtration.

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

Gas chromatography: Introduction, fundamentals, instrumentation, columns: preparation and operation, detection, dramatization. **Liquid chromatography:** HPLC-Principles and instrumentation, solvents and columns, detection and applications.

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

Spectroscopy: Introduction, electromagnetic spectrum. **UV-Visible spectroscopy:** absorbance laws and limitations, instrumentation-design and working principle, chromophore and auxochromes concept, Wood-Fisher rules for calculating absorption maximum, applications of UV-Visible spectroscopy. **IR spectroscopy:** Basic principles-Molecular vibrations, vibrational frequency, factors influencing vibrational frequencies, sampling techniques, instrumentation, interpretation of spectra, FT-IR, theory and applications.

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

Mass spectroscopy: Theory, ionization techniques: electron impact ionization, chemical ionization, field ionization, fast atom bombardment, plasma desorption, fragmentation process: types of fission, resolution, GC/MS, interpretation of spectra and applications for identification and structure determination. **X-ray diffraction (XRD):** Bragg's law, basic powder diffraction, generation of X-rays, Instrumentation, Scherrer equation, BCC and FCC Bravais lattice, phase identification using XRD.

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

NMR: Theory, instrumentation, chemical shift, shielding and de-shielding effects, splitting of signals, spin-spin coupling, proton exchange reactions, coupling constant (J), Nuclear OverHauser effect (NOE), ^{1}H NMR, ^{13}C NMR spectra and its applications.

Laboratory Sessions:

Paper chromatography: Separation of colored substances in a mixture by using different solvents as mobile phase. **UV-Vis spectroscopy:** Quantitative determination of various analytes in a given sample by UV-visible spectroscopy.

Scheme of Evaluation

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks obtained in each test)/3	CIE(50)	30
Quizzes		4
Assignments		8
Experiments related to courses		8
Semester End Examination	SEE(50)	50
	Total	100

Course outcomes:

CO1	Discuss classification of chromatography and explain Thin Layer, Gas Chromatography and High Performance Liquid Chromatographic methods
CO2	Discuss types of spectroscopy, instrumentation and applications of UV Spectroscopy
CO3	Explain theory, instrumentation and applications of IR spectroscopy
CO4	Discuss principle, instrumentation and applications of Mass Spectroscopy and NMR spectroscopy
CO5	Discuss principle, instrumentation and applications of X-ray diffraction

Text Books:	
1.	Instrumental Methods of Chemical Analysis by B.K. Sharma
Reference Books:	
1.	Organic Spectroscopy by Y.R Sharma
2.	Text book of Quantitative Chemical Analysis by Vogel's A.I.
3.	Organic Spectroscopy by William Kemp

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	CHEMICAL ENGINEERING DRAWING LAB	Semester	IV
Course Code	MVJ20CHL47	CIE	50
Total No. of Contact Hours	20 L:T:P::0:10:10	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to:

Draw the proportionate drawings of reaction vessel, jacked vessels, evaporator, STHE and also the assembly drawings of socket and spigot, flanged pipe and union joints etc with the help of solid edge software.

Sl No	Experiment Name	RBT Level	Hours
1.	**Sectional views:** Representation of the sectional planes, Sectional lines and hatching, selection of section planes and types of sectional views.	L1, L2, L3	3
2.	**Proportionate drawings:** Equipment and piping symbols, Vessels components: Vessel openings, Manholes, Vessel enclosures, Vessel support, Jackets, Shell and tube heat exchanger, Reaction vessel with the help of solid edge software and different types of Evaporators. P & I Diagrams.	L1, L2, L3	3
3.	**Assembly drawings:** Joints: Cotter joint with sleeve, Socket and Spigot joint, Flanged pipe joint, Union joint, Stuffing box and Expansion joint (Screw type or flanged type).	L1, L2, L3	3

Note:

- Assignments to be given to students to practice all the drawings and weightage shall given to these assignments while awarding IA marks.
-

jointly by Internal and External examiners. • Computer Aided drawing Software: Solid Edge or Equivalent Software.	
Course outcomes:	
CO1	Draw the general projections of given object.
CO2	Represent two-dimensional proportionate drawings of process symbols of various pipes and fittings.
CO3	Draw the proportionate drawings of reaction vessel, jacked vessels, evaporator, STHE and DPHE
CO4	Draw the assembly drawings of socket and spigot, flanged pipe and union joints showing sectional, front, top, and side views.
CO5	Demonstrate the usage of solid edge software tool for engineering drawing.

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	1	--	--	3	--	--	--	--	--	--	--
CO2	3	1	--	--	3	--	--	--	--	--	--	--
CO3	3	1	--	--	3	--	--	--	--	--	--	--
CO4	3	1	--	--	3	--	--	--	--	--	--	--
CO5	3	1	--	--	3	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MECHANICAL OPERATIONS LAB	Semester	IV
Course Code	MVJ20CHL48	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:

- Analyse the efficiency of various size reduction equipment's, Average particle size analysis, and to evaluate filtration and sedimentation processes

Sl No	Experiment Name	RBT Level	Hours
1.	Ball mill- verify the crushing laws using given sample	L1, L2, L3, L4	3
2.	Batch sedimentation- determine area of thickener required for given sample	L1, L2, L3, L4	3
3.	Free settling- determine settling velocity of various samples	L1, L2, L3, L4	3
4.	Drop weight crusher- verify the crushing laws using given sample	L1, L2, L3, L4	3
5.	Sieve analysis-find the particle size distribution of the given sample	L1, L2, L3, L4	3
6.	Screen effectiveness-find the separation efficiency of given screen.	L1, L2, L3, L4	3
7.	Jaw crusher- verify the crushing laws using given sample	L1, L2, L3, L4	3
8.	Leaf filter-find the specific cake resistance	L1, L2, L3, L4	3
9.	Air elutriation - find the particle size distribution of the given sample	L1, L2, L3, L4	3
10.	Air permeability- find the specific surface area of the particles of a given sample	L1, L2, L3, L4	3
11.	Grindability index	L1, L2, L3, L4	3
12.	Froth floatation- Efficiency of frothing agent in separating given ore sample	L1, L2, L3, L4	3
13.	Plate and frame filter press - find the specific cake resistance	L1, L2, L3, L4	3

14.	Cyclone separator- Efficiency of separation	L1, L2, L3, L4	3

Course outcomes:	
CO1	Explain properties of particulate solids, handling and mixing of solid particles.
CO2	Analyse principles and different types of size reduction equipment's like crushers, grinders etc.
CO3	Evaluate the effectiveness of screening, filtration, sedimentation, of solids etc.
CO4	Evaluate energy requirements in solids handling, agitation and mixing, solid conveying and storage.
CO5	Conduct experiments on some of the basic unit operations such as separation size reduction.

Text Books:	
1.	McCabe, W. L., Smith, J. C., &Harriott, P. (1993). *Unit operations of chemical engineering* (Vol. 5, p. 154). New York: McGraw-hill.
2.	Badger, W. L., &Banchero, J. L. (2010). Introduction to chemical engineering. 25th reprint.

Reference Books:	
1.	McCoy, B. J. (1993). CHEMICAL ENGINEERING: Vol. 2. Particle Technology and Separation Processes, by JM Coulson, JF Richardson, JR Backhurst, and JH Harker. *Chemical Engineering Education*, *27*(3), 183-199.
2.	Montillon, G. H. (1951). Unit Operations. By GG Brown, AS Foust, DL Katz, R. Schneidewind, RR White, WP Wood, JT Banchero, GM Brown, LE Brownell, JJ Martin, GB Williams, and JL York. *The Journal of Physical Chemistry*, *55*(4), 614-616.

Viva		10
Write up	SEE (50)	10
Conduction		20
Analysis of results		10
Viva		10
Total		100

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	0	0	0	0	0	0	0	0	0
CO2	2	2	2	2	0	0	0	0	0	0	0	0
CO3	2	2	2	2	0	0	0	0	0	0	0	0
CO4	2	2	2	0	0	0	0	0	0	0	0	0
CO5	2	2	2	2	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW	Semester	IV
Course Code	MVJ20CPH49	CIE	50
Total No. of Contact Hours	15 L : T : P :: 15 :0 : 0	SEE	50
No. of Contact Hours/Week	01	Total	100
Credits	01	Exam. Duration	2 hrs

Course objective is to:

- To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.
-

Elections, Electoral Process, and Election Commission of India, Election Laws.

Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements).

Emergency Provisions, types of Emergencies and it's consequences.

Constitutional Special Provisions: Special Constitutional Provisions for SC & ST, OBC, Special Provision for Women, Children & Backward Classes.

Module – IV	**RBT Level: L1, L2, L3**	**3 Hours**

Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India) : Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. **Responsibilities in Engineering -** Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.

Module – V	**RBT Level: L1, L2, L3**	**3 Hours**

Internet Laws, Cyber Crimes and Cyber Laws:

Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.

Course Outcomes: On completion of this course, students will be able to	
CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.
CO3	Understand the cyber crimes and cyber laws for cyber safety measure.

Text Books:	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
Reference Books:	

1.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.) Prentice –Hall EEE, 19th/20thEdn., (Latest Edition) or 2008.
2.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.
3	M.Govindarajan, S.Natarajan, V.S.Senthilkumar, "Engineering Ethics", Prentice – Hall of India Pvt. Ltd. New Delhi, 2004.
4.	M.V.Pylee, "An Introduction to Constitution of India", Vikas Publishing, 2002.
5.	Latest Publications of NHRC - Indian Institute of Human Rights, New Delhi.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (40 marks each), the final IA marks to be awarded will be the average of three tests - Assignment (10 marks)
SEE Assessment:
i. Question paper for the SEE consists one part. It is compulsory and consists of objective type 1 mark each for total of 50 marks covering the whole syllabus. ii. Ten questions must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	**ADDITIONAL MATHEMATICS-II** **(COMMON TO ALL BRANCHES)**	**Semester**	IV
Course Code	MVJ20MATDIP41	**CIE**	50
Total No. of Contact Hours	40	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	-	**Exam. Duration**	3hrs

Course objective is to: This course viz., aims to prepare the students:

To familiarize the important tools Linear Algebra, differential Calculus, Beta and Gamma functions, 3-Dimentional Geometry and probability for analysing the engineering problems.

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

Linear Algebra: Introduction, Rank of a matrix-echelon form. Solution of system of linear equations – consistency. Gauss-elimination method and problems. Eigen values and Eigen vectors of square matrix of order two and Problems.

Video Link:

https://www.math.ust.hk/~machas/matrix-algebra-for-engineers.pdfhttps://nptel.ac.in/content/storage2/courses/122104018/node18.html

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

Differential calculus: Tangent and normal, both Cartesian and polar forms. Increasing and decreasing functions, Maxima and Minima for a function of one variable. Point of inflections and Problems. **Beta and Gamma functions:** Beta and Gamma functions, Relation between Beta and Gamma function-simple problems.

Video Link:

https://www.youtube.com/watch?v=6RwOoPN2zqE

https://www.youtube.com/watch?v=s6F5yjY6jWk&list=PLMLsjhQWWlUqBoTCQDtYlloI-o-9hxp11

http://tutorial.math.lamar.edu/Classes/DE/IntroPDE.aspx

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

Analytical solid geometry: Introduction –Directional cosine and Directional ratio of a line, Equation of line in space- different forms, Angle between two line, shortest distance between two line, plane and equation of plane in different forms and problems.

Video Link: https://www.toppr.com/guides/maths/three-dimensional-geometry/ https://www.toppr.com/guides/maths/three-dimensional-geometry/distance-between-skew-lines/		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Probability: Random variable, Discrete probability distribution, Mean and variance of Random Variable, Theoretical distribution- Binomial distribution, Mean and variance Binomial distribution -Problems. Poisson distribution as a limiting case of Binomial distribution, Mean and variance of Poisson distribution. Normal Distribution-Basic properties of Normal distribution –standard form of normal distribution and Problems. Video Link: https://nptel.ac.in/courses/111/105/111105041/ https://www.mathsisfun.com/data/probability.html		
Module-5	**RBT Level: L1, L2**	**8 Hours**
Partial differential equation: Formation of PDE's by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivative with respect to one independent variable only. Video Link: http://tutorial.math.lamar.edu/Classes/DE/IntroPDE.aspx https://www.studyyaar.com/index.php/module-video/watch/233-cauchys-legendres-de-a-method-of- variation-of-parameters		
Course outcomes:		
CO1	Apply the knowledge of Matrices to solve the system of linear equations and to understand the concepts of Eigen value and Eigen vectors for engineering problems.	
CO2	Demonstrate various physical models ,find Maxima and Minima for a function of one variable., Point of inflections and Problems .Understand Beta and Gamma function	
CO3	Understand the 3-Dimensional geometry basic, Equation of line in space-different forms, Angle between two line and studying the shortest distance.	
CO4	Concepts of Probability related to engineering applications.	
CO5	Construct a variety of partial differential equations and solution by exact methods.	

Text Books:	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition 2013.
2.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
Reference Books:	
1	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10thedition,2014.
2	G. B. Gururajachar: Calculus and Linear Algebra, Academic Excellent Series Publication, 2018-19

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (10 marks) - Assignment (10 marks)
SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii.

Course Title	**TECHNICAL MANAGEMENT & ENTREPRENEURSHIP**	Semester	V
Course Code	MVJ20TEM51	**CIE**	50
Total No. of Contact Hours	40 L: T : P :: 40 : 00 : 00	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3Hrs

Course objective: This course will enable students to

- Introduce the field of management, task of the manager, importance of planning and types of planning, staff recruitment and selection process.
-

Organizing and Staffing: Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalization, Committees – meaning, Types of Committees, Centralization Vs Decentralization of Authority and Responsibility, Span of Control,

Nature and Importance of Staffing, Process of Selection and Recruitment.

Directing and Controlling: Meaning and Nature of Directing-Leadership Styles, Motivation Theories,

Communication – Meaning and Importance, Coordination- Meaning and Importance,

Techniques of Coordination. Controlling – Meaning, Steps in Controlling.

Laboratory Sessions/ Experimental learning

- Case study of steel plant departmentalization. Applications
-

definitions of SSI Enterprises, Government policy and development of the Small Scale sector in India, Growth and Performance of Small Scale Industries in India, Sickness in SSI sector, Problems for Small Scale Industries, Impact of Globalization on SSI, Impact of WTO/GATT on SSIs, Ancillary Industry and Tiny Industry (Definition only).

Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central– Level Institutions, State-Level Institutions.

Laboratory Sessions/ Experimental learning

Case study on the growth of small-scale industries. Application

Small Scale Industries

Web Link and Video Lectures

https://www.slideshare.net/syedmubarak15/institutional-support-for-business-enterprises

https://www.wto.org/english/docs_e/legal_e/gatt47_01_e.htm

Module-5	RBT Level: L1, L2	8 Hours

Project Management: Meaning of Project, Project Objectives & Characteristics, Project Identification- Meaning & Importance; Project Life Cycle, Project Scheduling, Capital Budgeting, Generating an Investment Project Proposal, Project Report-Need and Significance of Report, Contents, Formulation, Project Analysis-Market, Technical, Financial, Economic, Ecological, Project Evaluation and Selection, Project Financing, Project Implementation Phase, Human & Administrative aspects of Project Management, Prerequisites for Successful Project Implementation. New Control Techniques- PERT and CPM, Steps involved in developing the network, Uses and Limitations of PERT and CPM.

Laboratory Sessions/ Experimental learning

- Investigation on the market in correspondence to project.
-

Activities / Experimentations related to courses	)	8
Mini Projects / Case Studies		8
Semester End Examination	SEE (50)	50
	Total	100

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

CO1	Understand the concept of Management
CO2	Understand the staffing process
CO3	Explain the social responsibilities of business towards Different Groups
CO4	Explain the Role of Small Scale Industries
CO5	Interpret the Project Objectives

Reference Books:

1.	Stephen P. Robbins & Mary Coulter, Management‖, Prentice Hall (India) Pvt. Ltd., 10th Edition, 2009
2.	JAF Stoner, Freeman R.E and Daniel R Gilbert , Management‖, Pearson Education, 6th Edition, 2004.
3.	Stephen A. Robbins & David A. Decenzo& Mary Coulter, Fundamentals of Management‖ Pearson Education, 7th Edition, 2011.
4.	Robert Kreitner& Mamata Mohapatra, Management‖, Biztantra, 2008.
5.	Harold Koontz & Heinz Weihrich , "Essentials of management",‖ Tata McGraw Hill,1998.
6.	Tripathy PC & Reddy PN, "Principles of Management" , Tata McGraw Hill, 1999

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	CHEMICAL REACTION ENGINEERING - II	Semester	V
Course Code	MVJ20CH52	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 and apply the principles of non-ideal flow in the design of reactor.
-

Experiential Learning: Understanding the solid-combustion reactions with real-life examples.

Applications: The chemical and energy industries rely heavily on heterogeneous catalysis, because it enables faster, large-scale production and the selective product formation.

Video Links:

https://nptel.ac.in/courses/103/106/103106117/

https://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reaction-engineering-spring-2007/

https://pubs.rsc.org/am/content/articlehtml/2012/cy/c2cy90039d

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

Catalysis: Introduction to catalysis. Properties of catalysts. Estimation methods for catalytic properties. Promoters, inhibitors etc, Mechanism of catalysis. Rate equations for different rate controlling step. **Deactivation**: Deactivating catalyst. Mechanism, rate & performance equation.

Experiential Learning: Demonstrating catalyzed versus uncatalyzed reaction with an example and showing improvement of rate of reaction in case of catalyzed reaction.

Applications: Catalytic processes concerns the large fields of the hydrocarbon's transformation into intermediates and final products.

Video Links:

https://application.wiley-vch.de/books/sample/352730715X_c01. pdf

https://www.essentialchemicalindustry.org/processes/catalysis-in-industry.html

https://www.eolss.net/sample-chapters/C06/E6-190-03-00.pdf

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

Solid Catalyzed Reactions: Heterogeneous reactions- Introduction, Kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Thiele modulus and enhancement factor, Porous catalyst particles. Heat effects during reaction. Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates.

Experiential Learning: Identifying some solid-catalyzed reactions in daily-life routine.

Applications: Students can understand the mechanism of catalyzed reactions used

to accelerate the rate by which a specific chemistry proceeds and the action of the catalyst is to provide an alternative, lower energy pathway for the reaction.

Video Links:

https://www.itcp.kit.edu/deutschmann/download/III_12_2009_UllmannEncycl_HetCatal_Turek_Deutschmann.pdf

https://www.mt.com/in/en/home/applications/L1_AutoChem_Applications/L2_ReactionAnalysis/Catalytic-Reactions.html

Module-5	RBT Level: L1, L2, L3	10 Hours

Solid Catalyzed Reactions (Contd.): Packed bed catalytic reactor & reactors with suspended solid catalyst. Fluidized reactors of various types. Gas-Liquid Reactors: Trickle bed, slurry reactors. Three phase fluidized bed. Industrially important Catalyst, Basic concepts of green catalysis, applications of environmental catalysts.

Experiential Learning: Identifying green catalysts substitutes for specific reactions, with examples.

Applications: Students can understand the performance equation of solid catalysed reaction in various reactors with industrial application of green catalysis.

Video Links:

https://www.itcp.kit.edu/deutschmann/download/III_12_2009_UllmannEncycl_HetCatal_Turek_Deutschmann.pdf

http://nptel.ac.in/courses/103101008/

https://nptel.ac.in/courses/103/101/103101141/

https://www.ualberta.ca/science/green-chemistry-catalysis.html

Course outcomes:

CO1	Interpret non ideality in a reactor using RTD data and predict conversion using various models like Dispersion and tanks in series model.
CO2	Develop the rate equations for heterogeneous fluid particle systems and the fluid -fluid non catalytic reactions to solve problems.
CO3	Derive the rate expressions for heterogeneous catalytic reactions and Catalytic deactivation.
CO4	Analyze different steps in reaction mechanisms on solid catalytic surfaces and identify the factors affecting rate.
CO5	Derive the performance equation of solid catalysed reaction in various reactors with industrial application of green catalysis.

Text Books:

1	Levenspiel, O. (1998). *Chemical reaction engineering*. John wiley & sons.
2	Fogler, H. S. (2010). *Essentials of Chemical Reaction Engineering: Essenti Chemica Reactio Engi*. Pearson Education.
Reference Books:	
1	Smith, J. M. (1981). *Chemical engineering kinetics* (No. TP149 S58).
2	Carberry, J. J. (2001). *Chemical and catalytic reaction engineering*. Courier Corporation.

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	2	3	--	--	--	--	--	--	--	--
CO2	3	3	2	--	--	--	--	--	--	--	--	--
CO3	3	2	--	--	--	--	--	--	--	--	--	--
CO4	3	3	--	--	--	--	--	--	--	--	--	--
CO5	3	3	2	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	MASS TRANSFER – I	Semester	V
Course Code	MVJ20CH53	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:

- Formulate equations for estimation of diffusivities in fluids & solids using first principles of engineering sciences.
-

Design of cooling towers.

Experiential Learning: Experiment to determine the overall heat transfer coefficient in a forced draft counter current cooling tower. To measure Tower Characteristic parameter KV/L for various liquid and air flow rates (L/G) in a counter-current Forced draft Cooling Tower.

Applications: It helps in understanding the humidification of gases for the controlled drying of wet solids. Mostly it is used for the drying of the food grade products, then dehumidification and cooling of the gas in the air conditioning machine, gas cooling with the help of water and cooling of liquid before reuse with the help of this cooling tower

Video Links/Any other special information (Papers):

https://onlinecourses.nptel.ac.in/noc20_ch15/preview

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

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

Drying: Introduction, Equilibria, Drying rate curves. Mechanism of drying, types of dryers. Design of batch and continuous dryers.

Experiential Learning: Experiment to study the drying characteristics using vacuum dryer. To study the drying characteristics by drying the given sample in a tray Dryer and to determine the mass transfer and heat transfer co-efficient.

Applications: Mass transfer process consisting of the removal of water or another solvent by evaporation from a solid, semi-solid or liquid. This process is often used as a final production step before selling or packaging products.

Video Links/Any other special information (Papers):

https://nzifst.org.nz/resources/unitoperations/documents/UnitopsCh7.pdf

https://www.chemengonline.com/solids-drying-basics-and-applications/?printmode=1

https://nptel.ac.in/content/storage2/courses/103103027/pdf/mod4.pdf

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

Adsorption: Theories of adsorption. Isotherms, Industrial adsorbents. Equipment, Batch & continuous multistage adsorption.

Experiential Learning: Experimental Study of Adsorption on Activated Carbon for CO_2 Capture. Batch Sorption Studies: Freundlich and Langmuir Isotherms.

Applications: Some of the applications of various adsorbents like charcoal is used to decolorize as it adsorbs the coloring matter from the colored solution of sugar, Silica gel adsorbing moisture from the desiccators, Silica and alumina gels for removing moisture and for controlling humidity of rooms.

Video Links/Any other special information (Papers):

http://home.eng.iastate.edu/~tge/ce326/518-527.pdf

https://www.aiche.org/sites/default/files/docs/pages/adsorption_basics_part_1.pdf

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

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

Crystallization: Factors governing nucleation and crystal growth rates. Controlled growth of crystals. Incorporation of principles into design of equipment. Different types of crystallizer equipment.

Introduction to Separation Techniques: Ion exchange, Membrane Processes-Reverse Osmosis, Dialysis, Ultra and Micro-filtrations, Super-critical fluid extraction. (Working principle and operations only)

Experiential Learning: Experiment to prepare pure crystals from an impure sample. Pure samples can be obtained using Crystallizers.

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://nitsri.ac.in/Department/Chemical%20Engineering/MT-I.pdf

http://www.eolss.net/ebooks/Sample%20Chapters/C06/E6-34-03-02.pdf

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

Course outcomes:

CO1	Explain the principles of diffusion in solids and fluids and interpret the behaviour the mass transfer coefficients using various theories and HTU and NTU concepts.
CO2	Explain concepts, application of humidification, dehumidification and design of cooling towers.
CO3	Comprehend operation, concepts and types of dryers.
CO4	Explain various isotherms, modes of adsorption operations, types of adsorber

	and design of packed bed adsorber.
CO5	Apply principles of crystallisation in design of crystalliser and illustrate the working principle of various novel separation techniques.
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.
3	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., & Andersen, L. B. (2008). Principles of unit operations. John Wiley & Sons.

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	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	-	-	-	-	-
CO5	3	3	2	-	-	-	-	-	-	-	-	-

High-3, Medium-2, Low-1

Course Title	INDUSTRIAL POLLUTION CONTROL	Semester	V
Course Code	MVJ20CH54	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 enhance knowledge and skills in the areas of importance of pollution, analysis & treatment of wastewater, polluted air, solid waste, noise and its control.

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

Introduction: Importance of environment for mankind. Types of pollution. Damages from environmental pollution. Need of environmental legislations and environmental Acts in India. Environmental Impact Assessment and Challenges. Functions of central and state pollution control boards. **Sampling and Analysis of Wastewater:** Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Types of water pollutants and their effects.

Experiential Learning: Demonstrating environment impact assessment with a case study on chemical industry.

Applications: It will give insight of environmental laws and to create environmental awareness and to promote environmental education. The sampling and analysis of wastewater will help them to understand the detail procedure of sampling which is the primary step in the design of a wastewater treatment plant

Video Links:

https://nptel.ac.in/courses/103/107/103107084/

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

Wastewater Treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Advanced wastewater treatment. Recovery of materials from process effluents. **Applications to Industries:** Norms and standards of treated water. Origin, characteristics, and treatment methods in typical industries – petroleum refinery, pulp and paper, distillery, and textile processing.

Experiential Learning: Demonstration of wastewater treatment in various chemical industries by videos/animations.

Applications: The students will understand the experimental process relates to unit processes in a water treatment facility. It helps them to understand the treatment and removal of potentially harmful contaminants from different Chemical industries. **Video Links:** https://nptel.ac.in/courses/103/107/103107084/ https://nptel.ac.in/courses/105/105/105105048/ https://www.youtube.com/watch?v=zVZ9c6EXfTA		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Air Pollution: Nature of air pollution. Classification of air pollutants. Sources of air pollutants. Air quality criteria and standards. Plume behaviour and dispersion of air pollutants. Sampling of pollutants. Methods of estimation of air pollutants. **Experiential Learning:** Demonstration on sampling of air pollutants using samplers. **Applications:** Sampling and estimation of air pollutants is to check the environmental air is meeting regulatory standards. **Video Links:** https://nptel.ac.in/courses/105/102/105102089/ https://nptel.ac.in/courses/103/106/103106162/ http://www.nptelvideos.in/2012/11/environmental-air-pollution.html		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Air Pollution Control: Control methods for particulates and gaseous pollutants. Air pollution control methods and equipment. Source collection methods: raw material changes, process changes, and equipment modification. Air pollution Control equipment. Origin, control methods, and equipment used in typical industries-metallurgical industries, and cement industries. **Experiential Learning:** Demonstrate the air pollution control using electrostatic precipitators and bag filter. **Applications:** Control equipment has applications in a wide range of industries, preventing the release of chemicals, vapors, and dust and filtering and purifying the air within the work environment. **Video Links:** https://nptel.ac.in/courses/103/106/103106162/ https://nptel.ac.in/courses/103/107/103107084/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**

Solid Waste Management: Origin, Classification and microbiology. Engineered systems for solid waste management – generation, onsite handling, storage, collection, transfer and transport, composting, sanitary land filling. **Noise Pollution:** Generation of noise, control strategies in industries. Recent trends in industrial waste management, Cradle to grave concept, Lifecycle analysis, Clean technologies.

Experiential Learning: To determine the percentage moisture content and volatile fatty acids present in the solid waste sample.

Applications: The solid waste treatment is for reducing and eliminating adverse impacts of waste materials on human health and the environment to support economic development and superior quality of life. Clean technology will help in reducing greenhouse gas productions.

Video Links:

nptel.ac.in/courses/120/108/120108005/

https://nptel.ac.in/courses/112/104/112104227/

https://www.sciencedirect.com/topics/earth-and-planetary-sciences/clean-technology

Course outcomes:	
CO1	Discuss the fundamentals of environmental pollution and the associated legal aspects.
CO2	Explain various wastewater treatment methods and the origin, characteristics, and treatment methods in typical industries.
CO3	Interpret the aspects of air pollution and the methods of estimating various air pollutants.
CO4	Outline the control strategies for industrial air pollution control to be within the ambit of environmental regulations.
CO5	Explain different techniques for municipal solid waste management, noise pollution and the recent trends in industrial waste management.

Text Books:	
1	Rao, C. S. (2007). *Environmental pollution control engineering*. New Age International.
2	Mahajan, S. P. (1985). *Pollution control in process industries*. Tata McGraw-Hill Education.

Reference Books:	
1	Mudakavi, J. R. (2010). *Principles and practices of air pollution control and analysis*. IK International Pvt Ltd.
2	Dara, S. S., & Mishra, D. D. (2006). *A textbook of environmental chemistry and pollution control*. S. Chand Publishing.

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 - 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	3	3	--	--	--	3	3	3	--	--	--	--
CO2	3	3	--	--	--	3	3	3	--	--	--	--
CO3	3	3	--	--	--	3	3	3	--	--	--	--
CO4	3	3	--	--	--	3	3	3	--	--	--	--
CO5	3	3	--	--	--	3	3	3	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PETROLEUM REFINERY ENGINEERING	Semester	V
Course Code	MVJ20CH551	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 history, classification of petroleum crudes.
- Understand the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products.

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

Introduction to petroleum refinery: Refinery overview, major refineries in India, markets, offshore and onshore, oil well technology.

Physical properties and classification of crude oils: Composition of petroleum, laboratory tests, refinery feed stocks and products, evaluation of crude oil properties, thermal properties of petroleum fractions.

Experiential Learning: To determine the flash point and fire point of a fuel.

Applications: Crude oil assay data help refineries determine if a crude oil feedstock is compatible for a particular petroleum refinery or if the crude oil could cause yield, quality, production, environmental and other problems.

Video Links:

https://nptel.ac.in/courses/103/102/103102022/

https://www.youtube.com/watch?v=PdStB9z37eA

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

Crude Pre-treatment: Pumping of crude oils. Dehydration of crude by chemical, gravity, centrifugal, electrical de-salter. Heating of crude- heater, different types of pipe still heaters including box type, cylindrical etc. Crude distillation, arrangement of towers for various types of reflux. Design concept of crude oil distillation column design. Atmospheric and Vacuum Distillation.

Experiential Learning: To demonstrate the crude pre-treatment using videos/animations. **Applications:** This is the first and most basic step in the refining process and is the precursor to cracking and reforming. **Video Links:** https://nptel.ac.in/courses/103/102/103102022/ https://www.youtube.com/watch?v=mn-u-7fRQv4 https://www.youtube.com/watch?v=LcMT6k_loi8		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Thermal Cracking: Thermal cracking reactions- theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials. Vis breaking, Cracking for the production of gasoline. **Catalytic Cracking:** Theory, feed stock and catalytic cracking conditions, Catalytic cracking processes. Fixed bed crackers. Moving bed crackers. Fluid catalytic cracking, Houdri flow process, flexi cracking-ortho-flow reactor. **Experiential Learning:** Demonstration of thermal and catalytic cracking using videos/animations. **Applications:** Cracking is the most important process for the commercial production of gasoline and diesel fuel. **Video Links:** https://nptel.ac.in/courses/103/102/103102022/ https://www.youtube.com/watch?v=K-shupztU78 https://www.e-education.psu.edu/fsc432/content/fluid-catalytic-cracking-fcc		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Catalytic Reforming: Theory of reforming. Reaction Conditions, reforming catalysts and factors influencing reforming, reforming catalysts, feedstock requirements. Catalytic reforming, Houndi forming, flexi forming, Rhein forming. **Naphtha cracking:** Theory, naphtha cracking for ethylene as feed selection and gas yield. Hydro cracking. Theory of hydro cracking. Catalysts for hydro cracking. **Experiential Learning:** Synthesis of zeolite catalyst from natural sources.		

Applications: Catalytic reforming is the process of converting low octane naphtha into high-octane reformate products. **Video Links:** https://nptel.ac.in/courses/103/102/103102022/ https://www.youtube.com/watch?v=7ct8QsBn5G8		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Coking: Theory of coking. General methods of petroleum coke production, various types of coking processes. Delayed coking, fluid coking, contact coking, flexi coking. **Hydro cracking:** Theory of hydro cracking. Catalysts for hydro cracking. Environmental issues and new trends in petroleum refinery operations. **Experiential Learning:** Demonstration on hydrocracking with a case study on a petroleum refinery. **Applications:** Coking is a refinery unit operation that upgrades material called bottoms from the atmospheric or vacuum distillation column into higher-value products and produces petroleum coke—a coal-like material. Hydrocracking is an important source of diesel and jet fuel. **Video Links:** https://nptel.ac.in/courses/103/102/103102022/ https://www.youtube.com/watch?v=8a93jdNA-xw https://www.youtube.com/watch?v=SvhbVt5RKCg		
Course outcomes:		
CO1	Outline the overview of the modern, integrated petroleum refinery, its feedstocks, product state and the processes employed to convert crude oil and intermediate streams into finished products.	
CO2	Classify the various treatment techniques employed in petroleum refining for the production of wide spectrum of useful products.	
CO3	Discuss the thermal and catalytic cracking methods employed in petroleum refinin	
CO4	Identify suitable refining technology for maximizing the product yield.	
CO5	Interpret the coking and the hydrocracking process employed and the environmental issues and new trends in petroleum refining.	

Text Books:	
1	Rao, B. (2002). *Modern Petroleum Refining Processes*l. Oxford & IBH Publishing.
2	Nelson, W. L. (1958). Petroleum refinery engineering.
Reference Books:	
1	Prasad, R. (2000). *Petroleum refining technology*. Khanna.
2	Bland, W. F., & Davidson, R. L. Petroleum processing handbook. [Book chapter].

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**
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	2	--	--	--	--	1	--	--	--	--	--
CO2	3	2	--	--	--	1	2	--	--	--	--	--
CO3	3	2	--	--	--	--	2	--	--	--	--	--
CO4	3	2	--	--	--	--	--	--	--	--	--	--
CO5	3	2	--	--	--	3	3	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	COLLOID AND INTERFACIAL SCIENCE	Semester	V
Course Code	MVJ20CH552	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 hrs

Course objective is to:

- Learn basic concepts of colloids and interfaces; properties of colloidal dispersions; surfactants and their properties.
- Acquire knowledge of surface and interfacial tension; Young–Laplace equation; Kelvin equation; contact angle; intermolecular and surface forces.
-

forces (Keesom, Debye, and London Interactions).

Experiential learning: Preparation of emulsion solution

Application: Surfactant is required for preparing soap

Video link / Additional online information:

https://www.youtube.com/watch?v=angDXLbq714&ab_channel=GargUniversity

https://nptel.ac.in/courses/103/106/105106204/

https://nptel.ac.in/content/storage2/courses/103105060/Sde_pdf/Module-06.pdf

https://nptel.ac.in/content/storage2/courses/103104045/pdf_version/lecture21.pdf

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

Thermodynamics of Interfaces: Thermodynamic treatment of interfaces, Surface and interfacial Tension. Temperature dependence of the surface tension, Surface free energy, Surface tension for curved interfaces, Surface excess and Gibbs adsorption isotherm. **Wetting fundamentals and Contact Angles**: method for measurement of Surface Tension, Concept of adhesion, cohesion, contact angle, Wetting Young-Laplace equation, Dynamic properties of interfaces, Surface viscosity, Kelvin equation.

Experiential learning: Demonstrate the measurement of Surface Tension of bubble, Isotherm study with varying temperature in adsorption experiment

Application: The Young–Laplace equation relates the pressure difference to the shape of the surface or wall, and it is fundamentally important in the study of static capillary surfaces Isotherm study in adsorption

Video link / Additional online information:

https://nptel.ac.in/courses/103/106/105106204/

https://www.youtube.com/watch?v=_9nUYB_O6uI&ab_channel=ETHZ-PhysicalChemistryofBuildingMaterials

https://www.youtube.com/watch?v=pmagWOkQ0M&ab_channel=khanacademymedicine

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

Electrical aspects of surfaces: Electrical phenomena at interfaces (Electronic kinetic phenomena, Electric double layer, short range forces). DLVO theory, capillary hydrostatics. Zeta potential, Electro osmosis phenomena, Streaming potential, Electro viscous flows.

Experiential learning: Measurement of Zeta Potential

Application: Zeta potential is used in adsorption study

Video link / Additional online information:

https://nptel.ac.in/courses/103/106/105106204/

https://www.youtube.com/watch?v=QKdX9HpQclE&ab_channel=AmericanWaterCollege

https://www.youtube.com/watch?v=HDQ8ct4md-8&ab_channel=Charge

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

Applications: Applications in detergents, personal-care products, pharmaceuticals, nanotechnology and food, textile, paint and petroleum industries.

Experiential learning: Demonstrate the preparation process of detergent, paint, textile industries.

Application: Applications in detergents, personal-care products, pharmaceuticals, nanotechnology and food, textile, paint and petroleum industries.

Video link / Additional online information:

https://nptel.ac.in/courses/103/106/105106204/

https://www.youtube.com/watch?v=s3yWnM2Y-rw&t=27s&ab_channel=Flexiguru

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
Mini Projects/ Case studies - 3Nos.		3X2=6
Semester End Examination	SEE (50)	50
Total		100

Course Outcomes:

CO1	Understand basic concepts of colloids and interfaces; properties of colloidal dispersions
CO2	Study of surfactants and their properties and forces involve in colloid surface
CO3	Provide fundamental background of thermodynamics of Interfaces, Surface

	tension for curved interfaces, Surface excess and Gibbs adsorption isotherm and Wetting fundamentals and contact angles
CO4	Study of DLVO theory; adsorption at interfaces; characterization of solid surfaces
CO5	Applications in detergents, personal-care products, pharmaceutic nanotechnology and food, textile, paint and petroleum industries.

Text Books:

1	Hiemen, P.C &Rajgopalam, R. (1997) Principle of Colloid and Surface Chemistry, Marcel Dekker.
2	Shaw, D.J. (1992). Colloid and surface chemistry, Butterworth Heineman, Oxford.

Reference Books:

1	Adamson, A.W. & Gast, A.P. (1997) Physical Chemistry of surfaces, Wiley Interscience, NY.
2	Israelachvili, J. (1992) Intermolecular and Surface Forces, Academic Press, New York.
3	Hunter, R.J. (2005). Foundations of Colloid Science, Oxford University Press, New York.

CO-PO Mapping:

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

High-3, Medium-2, Low-1

Course Title	FERMENTATION TECHNOLOGY	Semester	V
Course Code	MVJ20CH553	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 Hours

Course objective is to:

- Empower the students with various fermentation technologies and designs of fermenter.
-

the dilution method using aseptic techniques.

Applications:

Microorganisms are useful in producing foods, treating wastewater, creating biofuels and a wide range of chemicals and enzymes.

Video link / Additional online information:

https://nptel.ac.in/courses/102/105/102105058/

https://www.youtube.com/watch?v=fF2OP76pxZE

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

Sterilization: Media sterilization, Batch and Continuous Sterilization, Filter sterilization, Insitu sterilization in fermenter, The aseptic inoculation of plant fermenters.

Fermenter: Fermenter, Basic function of a fermenter for microbial or animal cell culture, body construction, and various parts of a fermenter, design and types, alternative vessel design, common measurements and control systems, anaerobic fermentation

Experiential learning: To demonstrate the parts of the fermenter and the working of fermenter using videos.

Applications:

Sterilization destroys all microorganisms on the surface of an article and in pharmaceutical manufacturing, biotechnology, or research laboratories, sterilization is critical to the integrity of your finished product.

Video link / Additional online information:

https://nptel.ac.in/courses/102/105/102105058/

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

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

Aeration and agitation: The oxygen requirements and supply of industrial fermentations, Determination of K_La, Factors affecting KLa values, balance between oxygen supply and demand, Modes of reactor operations.

Experiential learning: To demonstrate how to determine kLa using videos.

Applications: Aeration is to provide microorganism in submerged culture with sufficient oxygen for metabolic requirements. Agitation ensures that a uniform suspension of microbial cells is achieved in a homogenous nutrient medium.

Video link / Additional online information:

https://nptel.ac.in/courses/103/105/103105054/

https://nptel.ac.in/courses/102/105/102105058/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Important products through Fermentation: Organic acids: citric and acetic acid; enzymes: amylase, protease, lipase; antibiotics: penicillin; vitamins: vitB12; amino acids: lysine, Glutamic acid; organic solvents: ethanol, acetone butanol alcoholic beverages: wine, beer; biomass: baker's yeast; bio fertilizers; bio pesticides; bio surfactant; steroid transformation; biopolymers. **Experiential learning:** To carry out the synthesis of biopolymers. **Applications:** Fermentation products include anti-viral drugs, therapeutic recombinant proteins and DNA, and monoclonal antibodies, development of diagnostic kits, drug delivery vehicles and medical devices, targeted drug discovery etc. **Video link / Additional online information:** https://nptel.ac.in/courses/103/105/103105054/ https://nptel.ac.in/courses/102/105/102105058/		

Course outcomes:	
CO1	Comprehend the general requirement of fermentation and the microbial growth kinetics.
CO2	Explain the isolation, preservation and improvement of industrially important microorganisms.
CO3	Discuss the sterilization types, the design and operation of a fermenter.
CO4	Discuss the aeration and agitation requirements of industrial fermentations.
CO5	Integrate biological and engineering principles involved in the production and recovery of commercial products.

Text Books:	
1	Stan bury P.F., Whitaker A, Hall S. J. (2016). Principles of Fermentation Technology, 3rd edition, Saint Louis: Elsevier Science.
2	Shuler, M. L. &Kargi, F. (2001). Bioprocess Engineering: Basic Concepts, 2nd Edition, PHI.
Reference Books:	
1	Bailey, J. E., &Ollis, D. F. (2018). Biochemical engineering fundamentals. 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 – 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	2	--	--	--	--	--	--	--	--	--	--
CO2	3	2	--	--	--	--	--	--	--	--	--	--
CO3	3	2	1	--	--	--	--	--	--	--	--	--
CO4	3	2	--	--	--	--	--	--	--	--	--	--
CO5	3	2	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Name	POLYMER TECHNOLOGY	Semester	VI
Course Code	MVJ20CH633	CIE	50
No. of Contact hours / Week	4	SEE	50
Total No.of Contact hours	40 L : T : P :: 40 : 00 :00	Total	100
Credits	3	Exam. Duration	3 Hrs

Course Objectives: Understand the fundamental knowledge of polymeric systems, kinetics and mechanism of different polymerization.

1. Understand the structure and characterization of polymers.
2. Distinguish different types of polymers for various applications.
3. Understand plastics, manufacturing aspects, properties and uses.
4. Identify the processing technologies for polymeric synthesis and applications.

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

Polymer basics—Classifications based on occurrence, types, process, and end uses. Polymerization Kinetics and mechanism of free radical, cationic, anionic, living polymers and coordination polymerization–Ziegler Natta catalysts, stereo regular polymerization, chain transfer reaction and constant.

Laboratory Sessions/ Experimental learning: Synthesis experiment

Applications: polymers may find applications in electromagnetic interference (EMI) shielding and antistatic protection applications. Polymers can further be classified into three basic polymeric categories: thermoplastics, thermosets, and elastomers.

Video link / Additional online information:

https://nptel.ac.in/courses/104/105/104105039/

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

Structure, properties and reaction of polymers: Functionality, tactility of polymer, molecular weight, weight average, mechanical, thermal, electrical, rheological and optical properties, Reactions of polymer molecules with specific groups OH, CHO, C=O, COOH and $-NH_2$ and polymer–eross linking, cyclisation—polymer degradation, thermal, Mechanical, photo and radiation. Properties of Polymers.

Laboratory Sessions/ Experimental learning: To determine mechanical properties of polymer

Applications: Polymer applications include biomedical and biomimetic applications such

as drug **delivery** systems, biosensor devices, polymer-based bone grafts, fillings for teeth, dressings for cuts, biopolymers in molecular recognition, cosmetics, angioplasty and vascular stents, for catheters, in dialysis

Video link / Additional online information:

https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod16.pdf

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

Bio and inorganic polymers: Naturally occurring polymers, starch, proteins, cellulose, Derivatives of cellulose polymers, Rayon, cellophane, cellulose acetate, butyrate and nitrate, ethyl cellulose, carboxymethyl Cellulose-preparation, properties, application organo metallic polymers, co-ordination polymers, Polyamides, Inorganic polymers- phosphorous and silicones, Hybrid polymers.

Laboratory Sessions/ Experimental learning: designed and synthesized potential polymer inhibitors or inducers of polyglutamine protein aggregation

Applications: Inorganic polymers have wide applications such as in glasses, ceramics, rubber and plastic. Inorganic polymers are extensively used in petrochemical industries. Silicone rubber, another inorganic polymer product, is used in the building and construction industry for window and door seals.

Video link / Additional online information:

https://www.slideshare.net/krishnajadhav2/lipid-polymer-hybrid-nanoparticles.

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

Plastics: Feed stocks, Classifications, Resins, Plastics Natural & Synthetic, Code Identification. Olefins synthesis and production of LDPE, HDPE, CPE, homo and copolymers. Polypropylenes.

Laboratory Sessions/ Experimental learning: Bio-based plastics

Applications: Plastics is versatile, hygienic, lightweight, flexible and highly durable. It accounts for the largest usage of plastics world wide and is used in numerous packaging applications including containers, bottles, drums, trays, boxes, cups and vending packaging, baby products and protection packaging

Video link / Additional online information:

https://nptel.ac.in/courses/112/107/112107221

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

Engineering plastics: Acrylics, Poly- tetrafluoroethylene, feed stocks, Synthesis

Processing & Applications, Polymer processing technique (Casting, Moulding).

Laboratory Sessions/ Experimental learning: Viscoelastic behavior of polymers

Applications: Engineering plastics are used in applications including: Automotive, Electrical and electronics, Building and ***construction,*** Consumer goods and appliances, Industrial applications such as abrasion-resistant and corrosion-resistant liners.

Video link / Additional online information:

https://nptel.ac.in/courses/112/107/112107221/

Course outcomes: After studying this course, students will be able to:

CO1	Explain the classification, mechanism of polymerization.
CO2	Discuss structure, properties and reactions of polymers
CO3	Explain Bio And Inorganic Polymers
CO4	Understand and explain Feed stocks, Classifications and production of Resins, Plastics Natural Synthetic, plastics
CO5	Discuss engineering plastics and their applications

REFERENCE BOOKS:

1. F.W. Billemeyer, Text Book of Polymer Science, 3rdedn, John Wiley and sons, New York,2002.
2. R.J.Young,IntroductiontoPolymers,ChapmanandHallLtd.,London,1999.
3. Gorge Odeon, Principles of Polymerization, 4thedn, McGraw Hill Book Company, New York.2004.
4. Premamoy Ghosh, Polymer Science and Technology, 2ndedn, McGraw-Hill Publishing Company Limited, New Delhi,2003.
5.V.R.Gowarikar,PolymerScience,NewAgeInternationalPvt.LtdPublishers,2010.
6. G Aurora, M Singh, Introduction to Polymer Science, Amol Publications.

CO/PO Mapping:

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

Course Title	CHEMICAL REACTION ENGINEERING LAB	Semester	V
Course Code	MVJ20CHL56	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:

- Experimentally verify the principles and working of reactors studied in theory.
-

CO3	Study and use various reactors for determining rate constant and conversion.
CO4	Evaluate the data and compare with reported literature.
CO5	Apply theoretical knowledge of various types of reactors.
C06	Apply the use of skills in handling various reactors.

Text Books:	
1	Levenspiel, O. (1998). *Chemical reaction engineering*. John wiley& sons.
2	Fogler, H. S. (2010). *Essentials of Chemical Reaction Engineering: EssentiChemicaReactioEngi*. Pearson Education.
Reference Books:	
1	Smith, J. M. (1981). *Chemical engineering kinetics* (No. TP149 S58).
2	Carberry, J. J. (2001). *Chemical and catalytic reaction engineering*. Courier Corporation.

Scheme of Evaluation		
Details		**Marks**
Regular Lab Work	**CIE (50)**	**20**
Record Writing		**5**
Lab Test (minimum 2 tests shall be conducted for 15 marks and average of two will be taken)		**15**
Viva		**10**
Write up	**SEE (50)**	**10**
Conduction		**20**
Analysis of results		**10**
Viva		**10**
Total		**100**

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

High-3, Medium-2, Low-1

Course Title	HEAT TRANSFER LAB	Semester	V
Course Code	MVJ20CHL57	CIE	50
Total No. of Contact Hours	20 L : T : P :: 0 : 10 : 10	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to:

- Experimentally verify the Heat Exchanger concepts studied in theory.
-

CO2	Evaluate Thermal conductivity of a given metal Rod and composite wall and to very Fourier's law
CO3	Determine the Heat transfer coefficient for Fin, Forced convection, Natural Convection, and parallel and counter flow heat exchanger.
CO4	Test Emissivity, Stefan Boltzmann Constant and Critical Heat flux.
CO5	Asses the performance of different heat transfer equipment and Develop the ability to write laboratory reports
Text Books:	
1	Kern, D. Q., & Kern, D. Q. (1950). *Process heat transfer* (Vol. 5). New York: McGraw-Hill.
2	McCabe, W. L., Smith, J. C., &Harriott, P. (1993). *Unit operations of chemical engineering* (Vol. 5, p. 154). New York: McGraw-hill.
Reference Books:	
1	Coulson, J. M. (2001). *Chemical engineering*. Butterworth-Heinemann.
2	Rao, Y. V. C. (2001). *Heat Transfer*. Universities Press.
3	Dutta, B. K. (2000). *Heat transfer: principles and applications*. PHI Learning Pvt. Ltd.

Scheme of Evaluation		
Details		**Marks**
Regular Lab Work	**CIE (50)**	**20**
Record Writing		**5**
Lab Test (minimum 2 tests shall be conducted for 15 marks and average of two will be taken)		**15**
Viva		**10**
Write up	**SEE (50)**	**10**
Conduction		**20**
Analysis of results		**10**
Viva		**10**
Total		**100**

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

High-3, Medium-2, Low-1

Course Title	POLLUTION CONTROL & INSTRUMENTAL ANALYSIS LAB	Semester	V
Course Code	MVJ20CHL58	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:

- Experimentally verify the principles and working of reactors studied in theory.
-

Course outcomes:	
CO1	Analyse various parameters to assess pollution in water and air.
CO2	Interpret qualitative composition of a solution using instruments like Bomb calorimeter, Viscometer etc
CO3	Interpret quantitative composition of a solution using instruments like turbidometer, KF Auto titrator.
CO4	Analysis of Volatile, Fixed, Filterable and Dissolved solids
CO5	Measurement of particulate matter and SO2 in air.

Text Books	
1	Davis, W. T., &Buonicore, A. J. (Eds.). (2000). Air pollution engineering manual (pp. 117-135). New York: Wiley.
2	Baird, R. B. (2017). Standard methods for the examination of water and wastewater, 23rd.

Reference Books	
1	Dickinson, D. (1974). Practical waste treatment and disposal. Edited by Denis Dickinson. Compiled in collaboration with the Institute for Industrial Research and Standards, Dublin, Ireland..

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

High-3, Medium-2, Low-1

Course Title	ENVIRONMENTAL STUDIES	Semester	V
Course Code	MVJ20ENV59	CIE	50
Total No. of Contact Hours	15 L: T: P 15: 00 :00	SEE	50
No. of Contact Hours/week	1	Total	100
Credits	1	Exam. Duration	3 Hrs.

Course objective is to: This course will enable the students to

- Relatetointerdisciplinaryapproachtocomplexenvironmentalproblemsusingbasictoolsofthenatural and social sciences including geo-systems, biology, chemistry, economics, political science and international processes; Study drinking water quality standards and to illustrate qualitative analysis of water.
-

Module-3	RBT Level: L1, L2	3 Hours

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies): Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution. **Waste Management & Public Health Aspects:** Bio-medical Waste; Solid waste; Hazardous waste; E-waste.

Video link:

- https://nptel.ac.in/courses/122/106/122106030/
-

CO2	Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
CO3	Demonstrate ecology knowledge of a complex relationship between biotic and Abiotic components.

Scheme of Evaluation

Details		Marks
Average of three Internal Assessment (IA) Tests of 30 Marks each i.e. Σ (Marks Obtained in each test) / 3	CIE(50)	40
Quizzes		10
Semester End Examination	SEE (50)	50
	Total	100

Textbooks:

1.	Environmental Studies Benny Joseph Tata Mc Graw – Hill. 2nd Edition, 2012
2.	Environmental Studies S M Prakash Pristine Publishing House, Mangalore 3rd Edition, 2018.
CO4	Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Reference Books:

1.	Principals of Environmental Science and Engineering, Raman Siva kumar, Cengage learning, Singapur, 2nd Edition, 2005
2.	Environmental Science – working with the Earth G.Tyler Miller Jr. Thomson Brooks /Cole, 11th Edition, 2006
3.	Textbook of Environmental and Ecology, Pratiba Singh, Anoop Singh & Piyush Malaviya , ACME Learning Pvt. Ltd. New Delhi, 1st Edition.

CO-PO Mapping												
CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	3	3	3	1	–	2	2	1	1	–	2	1
CO2	3	3	2	1	–	1	2	–	1	1	2	1
CO3	3	3	2	1	–	2	2	–	1	1	2	1
CO4	3	3	2	2	–	2	2	–	1	1	2	1

High-3, Medium-2, Low-1

Course Title	**UNIVERSAL HUMAN VALUES II**	Semester	V
Course Code	MVJ20UHV510	**CIE**	50
Total No. of Contact Hours	30 L: T : P : 16 : 14 :0	**SEE**	50
No. of Contact Hours/week	2	**Total**	100
Credits	2	**Exam. Duration**	3 Hrs.

Course objective is to: This course will enable the students to

- Appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
-

- https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Module-2	RBT Levels: L1, L2	6 Hours

Review on Understanding Human being as the Co-existence of the Self and the Body, The Body as an Instrument of the Self, Harmony of the Self with the Body.

Harmony in the Human Being: Distinguishing between the Needs of the Self and the Body, Understanding Harmony in the Self, Programme to ensure self-regulation and Health.

Practical Sessions: Exploring the difference of Needs of Self and Body (Tutorial 4), Exploring Sources of Imagination in the Self (Tutorial 5), Exploring Harmony of Self with the Body (Tutorial 6).

Video link:

- https://www.youtube.com/watch?v=GpuZo495F24
-

- https://www.youtube.com/watch?v=lfN8q0xUSpw
- https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Module-5	RBT Levels: L1, L2	6 Hours

Review on Natural Acceptance of Human Values, Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Holistic Technologies, Production Systems and Management Models-Typical Case Studies.

Implications of the Holistic Understanding – a Look at Professional Ethics: Definitiveness of (Ethical) Human Conduct, Competence in Professional Ethics, Strategies for Transition towards Value-based Life and Profession

Practical Sessions: Exploring Ethical Human Conduct (Tutorial 12), Exploring Humanistic Models in Education (Tutorial 13), Exploring Steps of Transition towards Universal Human Order (Tutorial 14).

Video link:

- https://www.youtube.com/watch?v=BikdYub6RY0
-

Scheme of Evaluation

Details		Marks
Assessment by Faculty mentor (Class Room Evaluation)	CIE(50)	10
Self-Assessment + Assessment by peers		20
Activities / Experimentations related to courses/Assignment		10
Mini Projects / Case Studies		10
Semester End Examination	SEE (50)	50
	Total	100

Text Books:

1.	AICTE SIP UHV-I Teaching Material, https://fdp-si.aicte india.org/ AicteSipUHV _download.php
2.	A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1
3.	Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

Reference Books:

1.	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010
2.	Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3.	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4.	The Story of Stuff (Book).
5.	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi

CO-PO Mapping

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

High-3, Medium-2, Low-1

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.
-

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.
-

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.
-

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.
-

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
-

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
-

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
-

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.
-

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.
-

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.
-

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
-

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
-

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.
-

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)	10
Write up		
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.
-

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

Course Title	TRANSPORT PHENOMENA	Semester	VII
Course Code	MVJ20CH71	CIE	50
Total No. of Contact Hours	50 L : T : P :: 40 : 10 : 0	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- To introduce the students about basic laws of momentum, heat and mass transfer.
-

balances and boundary conditions through videos.

Applications: A common application of laminar flow is in the smooth flow of a viscous liquid through a tube or pipe. The walls of furnaces, boilers and other heat exchange devices consist of several layers.

Video link / Additional online information:

https://nptel.ac.in/courses/103/105/103105128/

Module-3	RBT Level: L-1, L-2, L3	10 Hours

Temperature Distribution in Solids and in Laminar Flow: Different situations of heat transfer: Heat conduction with internal generation by electrical and nuclear energy sources, Heat conduction in a cooling fin: Forced and free convection heat transfer. Concentration **Distributions in Laminar Flow**: Steady state Shell mass balances. General Boundary conditions applicable to mass transport problems of chemical engineering. Equimolar counter diffusion. Numerical problems.

Laboratory Sessions/ Experimental learning: Demonstration of shell mass balances and boundary conditions through videos.

Applications: Convective heat and mass transfer applications are heat exchangers, migration of moisture through air contained in fibrous insulation, energy efficient drying processes, underground spread of pollutants, packed-bed nuclear reactors, cooling of radioactive waste containers, microelectronic devices during their operation etc.

Video link / Additional online information:

https://nptel.ac.in/courses/103/105/103105128/

Module-4	RBT Level: L-1, L-2, L3	10 Hours

Concentration Distributions in Laminar Flow: Diffusion through stagnant gas and liquid films, Diffusion with homogeneous reaction, Diffusion with heterogeneous reaction Diffusion into falling film – Forced convection mass transfer. Numerical problems.

Laboratory Sessions/ Experimental learning: Demonstration of the effect of homogenous and heterogenous reaction using video.

Applications: Applications of diffusion are sintering to produce solid materials (powder metallurgy, production of ceramics), chemical reactor design, catalyst design in chemical industry.

Video link / Additional online information:

https://nptel.ac.in/courses/103/105/103105128/		
Module-5	**RBT Level: L-1, L-2, L3**	**10 Hours**
Analogies between Momentum, Heat and Mass Transport: Analogies between Momentum, Heat and Mass Transport - Reynold's, Prandtl's and Chilton & Colburn analogies. Equations of Change: Equation of continuity, Equation of motion; Navier – Stokes equation. Macroscopic Balance for Isothermal Systems (Mass, Momentum and Mechanical Energy Balance). **Laboratory Sessions/ Experimental learning:** Demonstration of analogy between heat and momentum transfer through videos. **Applications:** The common applications of equations of change are used in pipes, tubes and ducts with flowing fluids or gases, rivers, overall procedure as diaries, power plants, roads, logistics in general, computer networks and semiconductor technologies and some other fields. **Video link / Additional online information:** https://nptel.ac.in/courses/103/105/103105128/		

Course outcomes:	
CO1	Explain the basic transport equations for momentum, heat & mass transfer.
CO2	Develop the mathematical model to develop flux equations for steady state momentum and energy transfer in various situations.
CO3	Develop mathematical models to determine transfer fluxes and temperature, concentration distribution for heat sources and systems involving diffusion.
CO4	Develop the flux equations for steady state mass transfer in various situations.
CO5	Apply equation of change in solving steady state problems &analyse analogies between momentum, heat and mass transport.

Text Books:	
1	Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2006). *Transport phenomena* (Vol. 1). John Wiley & Sons.

Reference Books:	
1	B. M Suryavashi and L. R Dongre,(2015), *Transport phenomena*,7th edition, Niraliprakashann, 2015.
2	Brodkey, R. S., & Hershey, H. C. (2003). *Transport phenomena: a unified aprroach*. Brodkey publishing.

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	2	--	--	--	--	--	--	--	--	--	--
CO2	3	3	--	--	--	--	--	--	--	--	--	--
CO3	3	3	3	3	--	--	--	--	--	--	--	--
CO4	3	3	--	--	--	--	--	--	--	--	--	--
CO5	3	3	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PROCESS CONTROL	Semester	VII
Course Code	MVJ20CH72	CIE	50
Total No. of Contact Hours	50	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to:

- To determine possible control objectives, input variables (manipulated variables and disturbances).
-

Second Order Systems: Characteristics of manometer and damped vibrator. Transfer functions. Response for various input forcing functions, response for step input for under damped case – Terms associated with it. Transportation lag. **Closed Loop System:** Development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic controllers

Experiential learning: To study the characteristics of a damped vibrator.

Applications: Second order and closed loop systems are implemented widely in chemical industries such as mining, dredging, oil refining, pulp and paper manufacturing, chemical processing and power generating plants.

Video Links/Any other special information (Papers):

https://nptel.ac.in/courses/103/103/103103037/

https://ocw.mit.edu/courses/chemical-engineering/10-450-process-dynamics-operations-and-control-spring-2006/lecture-notes

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

Syllabus Content: **Stability:** Stability of linear control systems. Routh Test. **Frequency response:** Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, Principle of Nyquist diagram, stability criterion

Experiential learning: Demonstration of simulated closed loop response.

Applications: Frequency response techniques have been used to characterize an external recycle reactor and various chemical equipment.

Video Links/Any other special information (Papers):

https://nptel.ac.in/courses/103/103/103103037/

http://www.infocobuild.com/education/audio-video-courses/chemistry/ProcessControlInstrumentation-IIT-Kharagpur/lecture-24.html

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

Control System Design By Frequency Response: Bode criterion. Gain and Phase margins, Tuning of controller settings, Ziegler – Nichols controller tuning, Cohen-Coon controller tuning. **Root Locus:** Rules for plotting and problems.

Experiential learning: To demonstrate the tuning of controllers using videos. **Applications:** A process control engineer is using the frequency response analysis to select the most appropriate values for the adjustable parameters of a controller **Video Links/Any other special information (Papers):** https://nptel.ac.in/courses/103/103/103103037/ https://www.youtube.com/watch?v=sUDoTw_LIbk		
Module-5	**RBT Level: L1, L2, L3**	**10 Hours**
Advanced Control System: Introduction to advanced control systems, cascade control, feed forward control. **Introduction to computer control of chemical processes:** Digital Computer control loops **Experiential learning**: To demonstrate the multi loop control system-cascade control using videos. **Applications:** In computer process control, a digital computer is used to direct the operations of a manufacturing process and production operations involving materials such as chemicals, petroleum, foods, and certain basic metals. **Video Links/Any other special information (Papers):** https://nptel.ac.in/courses/103/103/103103037/ https://www.youtube.com/watch?v=B5jxoBiWB9g		

Course outcomes:	
CO1	Interpret the process control and modelling considerations and model the dynamics of a first order process.
CO2	Develop the transfer functions for a second system and derive the transient response of servo and regulator control with various control modes.
CO3	Analyze the stability for a given linear control systems using Routh Hurwitz criteria and the frequency response using Bode and Nyquist diagrams.
CO4	Analyze the control system design by frequency response and plot root locus diagram for different process.
CO5	Discuss cascade control, feed forward control and the digital digital computer control loops.

Text Books:	
1	Coughanowr, D. R., & Koppel, L. B. (1965). *Process systems analysis and control* (Vol. 2). New York: McGraw-Hill.

2	Stephanopoulos, G. (1984). *Chemical process control* (Vol. 2). New Jersey: Prentice hall.
Reference Books:	
1	Benenati, R. F. (1973). Process modeling, simulation and control for chemical engineers, William L. Luyben, McGraw-Hill, New York, 1973. 558 pp.
2	Coulson, J. M., Richardson, J. F., & Peacock, D. G. (1979). Chemical Engineering, Vol 3 (Chemical Reactor Design, Biochemical Reaction Engineering Including Computational Techniques and Control).

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**
Practical Examinations		**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	--	--	--	--	--	--	--	--	--	--
CO2	2	3	--	--	--	--	--	--	--	--	--	--
CO3	3	3	2	2	--	--	--	--	--	--	--	--
CO4	3	3	2	2	--	--	--	--	--	--	--	--
CO5	3	3	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	ADVANCED MEMBRANE SEPARATIONS	Semester	VII
Course Code	MVJ20CH731	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:

- Acquire in-depth knowledge in the areas of membrane separation mechanisms, membrane types and modules, membrane contactors / reactors and applications.
-

https://www.youtube.com/watch?v=cAjiMapprxM		
Module-3	**RBT Level: L1, L2, L3**	**8 Hours**
Membrane processes: Theory, system design, and applications of gas permeation, liquid membranes, membrane distillation, membrane contactors, membrane reactors and membrane bioreactors, and submerged membranes. **Experiential Learning:** Demonstrating the discussed membrane techniques and their mechanism of separation through animated videos. **Applications:** Industrial application of membrane science and technology for biotechnology and biomedical engineering. **Video Links/Any other special information:** https://www.thembrsite.com/membrane-filtration-technology-wastewater-treatment/ https://www.youtube.com/watch?v=cAjiMapprxM		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Concentration polarization and fouling: Polarisation phenomena and fouling concentration polarization (liquid separations), Gel layer model, Osmotic pressure model, Boundary layer resistance model, Characteristic flux behaviour in pressure driven membrane operation (gas separation process), membrane fouling, methods to reduce fouling. **Experiential Learning:** Demonstrating membrane fouling and their types. **Applications:** Solving membrane fouling issues industrially. **Video Links/Any other special information:** https://www.nature.com/articles/s41598-019-52369-1 https://www.youtube.com/watch?v=g9y-WXTKh5Q		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Membranes and modules: Isotropic membranes, anisotropic membranes, inorganic membranes, liquid membranes, hollow fibre membranes, membrane modules and their applications in the current world. Case study. **Experiential Learning:** Demonstrating types of membrane modules and their functioning. **Applications:** Industrially important membranes processes **Video Links/Any other special information**: https://synderfiltration.com/learning-center/articles/module-configurations-		

process/hollow-fiber-membranes/ https://www.youtube.com/watch?v=pYzZ9zJpCoY	
Course outcomes:	
CO1	History of membrane technology evaluation and practice.
CO2	Explain Nanofiltration, Reverse osmosis, Dialysis, piezodialysis, electrodialysis, Pervaporation and membrane distillation.
CO3	Design of Gas, Liquid and Ion exchange membranes in economical perspective
CO4	Design of membranes, Membrane fouling, Methods to reduce fouling.
CO5	Design of process modules and configurations of Membrane reactors for biotechnology.
Text Books:	
1	Richard W. B. (2012). Membrane Technology and Applications 3rd Edition. (John Wiley & Sons, Ltd., United Kingdom).
2	Li, N. N., Fane, A. G., Ho, W. W., & Matsuura, T. (Eds.). (2011). *Advanced membrane technology and applications*. John Wiley & Sons.
Reference Books:	
1	Philip, C. Wankat. (2005). Rate-Controlled Separations (Springer).
2	Ronald W Rousseau. (2008). Handbook of separation process technology. (Wiley India Pvt. Ltd.).
3	Web Link and Video Lectures: https://nptel.ac.in/courses/103103163/

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
Journals/Progress notes		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	2	--	--	--	--	--	--	--	--	--
CO2	3	3	3	--	--	2	2	--	--	--	--	1
CO3	3	3	3	--	--	2	2	--	--	--	--	1
CO4	3	3	3	--	--	--	--	--	--	--	--	--
CO5	3	3	3	--	--	2	2	--	--	--	--	1

High-3, Medium-2, Low-1

Course Title	PHARMACEUTICAL CHEMISTRY	Semester	VII
Course Code	MVJ20CH732	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:

- Learn formulations, tablet and capsule making.
-

Experiential Learning: Glycerol trinitrate synthesis **Applications:** Students will be able to understand the synthesis of Glycerol trinitrate and its medical uses. **Video Links/Any other special information:** https://nptel.ac.in/courses/103/107/103107082/		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Preparation: Test for purity and medical uses of Urea, ethylene diamine dihydrate, vanillin, and paraldehyde. **Preparation:** Test for purity and medical uses of lactic acid, citric acid, salicylic acid, saccharin sodium. **Experiential Learning:**Urea synthesis **Applications:** Students will be able to understand the synthesis of Urea and its applications **Video Links/Any other special information:** https://nptel.ac.in/courses/103/107/103107086/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Preparation: Test for purity and medical uses of Ethyl borate, dimethyl phthalate, and aspirin. **Experiential Learning:**Aspirin synthesis **Applications:** Students will be able to understand the synthesis of aspirin and its medical uses. **Video Links/Any other special information:** https://nptel.ac.in/content/storage2/courses/104103018/pdf/mod3.pdf		

Course outcomes:	
CO1	Explain electrophilic substitution reaction, its kinetics and mechanism.
CO2	Summarize mechanism & reactions of nucleophilic addition reaction
CO3	Illustrate the rheology of fluid mixing
CO4	Explain Preparation and Purity testing for compounds in medical application
CO5	Outline preparation, purity test and uses of acidic & ethyl borate, dimethyl phthalate & Aspirin

Text Books:	
1	Jain, N. K. (Ed.). (2006). *Pharmaceutical product development*. CBS publishers & distributors.
2	Morisson, T.R. and Boyd,R. (1992). Organic Chemistry, 6th edition. Prentice Hall of India Pvt Ltd., New Delhi.

Reference Books:	
1	Lachman, L., Lieberman, H. A., &Kanig, J. L. (1976). *The theory and practice of industrial pharmacy* (pp. 210-212). Philadelphia: Lea &Febiger.
2	Clayden, J., Greeves, N., Warren, S., &Wothers, P. (2001). Organic chemistry.
3	Web Link and Video Lectures: https://nptel.ac.in/courses/102/108/102108077/ https://nptel.ac.in/courses/104/102/104102113/ https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-bt23/

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
Journals/Progress notes		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	--	--	--	--	--	--	--	--	--	3	--
CO2	2	2	--	--	--	--	--	--	--	--	3	--
CO3	2	2	--	--	--	--	--	--	--	--	3	--
CO4	2	2	--	--	--	--	--	--	--	--	3	--

High-3, Medium-2, Low-1

Course Title	NOVEL SEPARATION TECHNIQUES	Semester	VII
Course Code	MVJ20CH733	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

- identify the multiple factors influencing the choice of separation techniques.
-

Video link / Additional online information:

https://www.youtube.com/watch?v=0-H195JR5i0

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

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

Surfactant Based Separations: Fundamentals. surfactants at inter phases and in bulk. liquid membrane permeation. foam separations. micellar separations. **Vapour Deposition:** Chemical vapor deposition (CVD) basics, atmospheric pressure chemical vapor deposition (APCVD), low pressure chemical vapor deposition (LPCVD), plasma enhanced chemical vapor deposition (PECVD), mass transfer control and reaction kinematics control.

Experiential learning: Learning about biosurfactants**,** demonstrate the plasma enhanced chemical vapor deposition by using NPTEL videos.

Applications: CVD has applications across a wide range of industries such as: coatings – coatings for a variety of applications such as wear resistance, corrosion resistance, high temperature protection, erosion protection and combinations thereof.

Video link / Additional online information:

https://www.youtube.com/watch?v=GIcVxvl7n84

https://www.youtube.com/watch?v=Ukvs6Rct4w8

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

Super Critical Fluid Extraction: Component of super critical fluid extraction (SFE), properties and modes of SFE, methods of developments of SFE, thermodynamics and physico chemical principles. process description. application. case study.

Experiential learning: A case study on supercritical fluid extraction versus traditional solvent extraction of caffeine from tea leaves.

Applications: The use of supercritical CO_2 as an extraction solvent for natural products is the oldest and the most developed process on an industrial scale, with applications especially in the food industry. decaffeination of coffee: this is the first example of the industrialization of supercritical fluids

Video link / Additional online information:

https://www.youtube.com/watch?v=0RCsmoqRGBY

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

Mechanical–Physical Separation Process: Introduction, classification, filtration in solid liquid separation. settling & sedimentation in particle fluid separation.

Other Separations: Separation by thermal diffusion, electrophoresis, crystallization.

Experiential learning: Identifying some examples related to solid-liquid separation in day-

to-day life.

Applications: Processes which depend primarily on physical forces to accomplish the desired separation of components are used quite commonly in most phases of the food industry. These processes are normally referred to as mechanical separations and include filtration, sedimentation, and centrifugation.

Video link / Additional online information:

https://www.youtube.com/watch?v=0WAc06ldbLs

Course Outcomes:	
CO1	Explain fundamentals of various types of advanced separation techniques.
CO2	Understand the given industrial separation/problem and apply concepts of advanced separation techniques.
CO3	Explore usage of alternative separation techniques to the existing ones.
CO4	Analyse and design pervaporation, chromatography, and dialysis-based separation processes.
CO5	Examine merits and limitations of novel separation techniques.

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	Rousseau, R. W. (Ed.). (1987). Handbook of separation process technology. John Wiley & Sons.
2	Geankoplis, C. J. (2003). Separation Process Principles.
Reference Books:	
1	Staude, E. (1991). Marcel Mulder: basic principles of membrane technology.
2	Wankat, P. C. (1990). Rate-controlled separations. Kluwer Academic Pub.
3	Wankat, P. C. (1986). Lg Scale Adsorption &Chromatogrpahy. CRC-Press.

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

High-3, Medium-2, Low-1

Course Title	NANOFABRICATION	Semester	VII
Course Code	MVJ20CH734	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 Hours

Course objective is to:

- Understand knowledge on the basic concept of nano fabrication
-

Spray Pyrolysis

Applications: Physical technique used for synthesis of nanoparticles

Video link / Additional online information:

1. https://www.youtube.com/watch?v=HhGCNG2X8gQ
2. https://www.youtube.com/watch?v=Z51R49OOqAA

Module-3	RBT Level: L-1, L-2, L3	8 Hours

Chemical methods: Chemical vapour deposition (CVD); plasma-enhanced CVD; low pressure plasma CVD; metalorganic CVD (MOCVD); photo-enhanced CVD; electron enhanced CVD; Laser induced CVD; atmospheric pressure CVD; reactive ion etching (RIE) molecular-beam epitaxy (MBE); chemical beam epitaxy (CBE); chemical bath deposition; electrochemical synthesis of nano structures. Sol- gel processing; fundamentals of sol-gel process; sol-gel synthesis methods for oxides; other inorganics and nano composites; the Pecheni method; silica gel; zirconia and Yttrium gel; aluminosilicate gel; polymer nano composites. Mechanochemistry: grinding and milling devices

Laboratory Sessions/ Experimental learning: Synthesis of cadmium sulphide nanoparticles by Sol-Gel Method

Applications: CVD processes widely use to deposit materials in various forms, including monocrystalline, polycrystalline, amorphous, and epitaxial.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=Z51R49OOqAA
2. https://www.youtube.com/watch?v=ULY7iprHlL

Module-4	RBT Level: L-1, L-2, L3	8 Hours

Self-assembly: Bottom-up approach. Self-assembly; self-assembled mono layers; directed assembly; layer-by-layer assembly; spontaneous formation & ordering of nano structures; nano-fluidics to build silicon devices with features comparable in size to DNA, proteins & other biological molecules; Langmuir Blodgett films; electrochemical self-assembly of oxide/dye composites. Self-assembled nano biomaterials; pattern definition; pallsin transfer; atomic & molecular manipulation; biomineralization; colloidal quantum dots; self-assembly techniques

Laboratory Sessions/ Experimental learning: Demonstrate the different self-assembly proceed

Applications: Self-assembly of nanostructures is a process where atoms, molecules or nanoscale building blocks spontaneously organize into ordered structures or patterns

with nanometer features without any human intervention. It is the most promising practical low-cost and high-throughput approach for nanofabrication

Video link / Additional online information:

https://www.youtube.com/watch?v=mad7Tasw75s.

https://www.youtube.com/watch?v=TgwpVGWL6dQ

https://www.youtube.com/watch?v=KXAEYdzG9U

Module-5	RBT Level: L-1, L-2, L3	8 Hours

LITHOGRAPHIC TECHNIQUES: Top-down approach to nanolithography; immersion lithography, EUV photolithography; phase shifting masks; x-ray lithography, including plasma x-ray sources; e-beam and focused ion-beam lithography; photo resist technologies for the nano scale; metrology and defect inspection. Soft lithography; nano imprint lithography; wet etching, dry etching (isotropic, anisotropic), pattern growth techniques (polymerization, directed assembly). Proximal probe nano lithography; STM; AFM; resists & imaging layers for proximal probes

Laboratory Sessions/ Experimental learning: Demonstrate on 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:

1. https://www.youtube.com/watch?v=nUXDltQfqSA
2. https://www.youtube.com/watch?v=nioYljr3oV8
3. https://www.youtube.com/watch?v=udXHWVejDj0

Course outcomes:

CO1	Understand the concept of the nano Fabrication method
CO2	Apply the knowledge of physical techniques for synthesis of nano structure
CO3	Apply the knowledge of Chemical techniques for synthesis of nano structure
CO4	Develop of the basic self-assembly and the different types of processing
CO5	Understand the lithographic Techniques

Text Books:

1	Nalwa, H. S. (2004). *Encyclopedia of nanoscience and nanotechnology. Volume 1, A-Ch*. American scientific publishers.

Reference Books:

1	Fahrner, W. R. (2005). *Nanotechnology and nanoelectronics*. Springer-Verlag

	New York Incorporated.
2	Frank, J. Owens and Charles, P. Poole (2003). *Introduction to Nanotechnology*. Wiley-IEEE.

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	2	--	--	--	--	1	--	--	--	--	--
CO2	3	2	1	--	--	1	1	--	--	--	--	--
CO3	3	2	1	--	--	1	1	--	--	--	--	--
CO4	3	2	1	--	--	1	1	--	--	--	--	--
CO5	3	2	1	--	--	1	1	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	COMPUTATIONAL FLUID DYNAMICS	Semester	VII
Course Code	MVJ20CH741	CIE	50
Total No. of Contact Hours	40 L : T : P :: 20: 0: 20	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to:

- To introduce Governing Equations of viscous fluid flows
-

Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods

Experiential Learning: Demonstrate the different applications of finite difference and finite volume methods with some example.

Application: Finite Difference Method: It is difficult to satisfy conservation and to apply for irregular geometries

Finite Volume Method: It tends to be biased toward edges and one-dimensional physics.

Video Links/Any other special information:

NPTEL: https://www.youtube.com/watch?v=vf0S_1ZITuA

https://onlinecourses.nptel.ac.in/noc20_me82/preview

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

https://www.youtube.com/watch?v=WwgrAH-IMOk

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

Solution algorithms: Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

Experiential Learning: Use Finite Difference and Finite Volume Methods in CFD Modelling

Application: Central Upwind Scheme used for Solving Special Relativistic Hydrodynamic Equations

Video Links/Any other special information:

1.https://www.youtube.com/watch?v=A-GCsFw68jw

2. https://www.youtube.com/watch?v=-kfKaxWf0JY

3.https://www.youtube.com/watch?v=wVgIJDrMpdQ

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

Flow field analysis: Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

Experiential Learning: Demonstrate the steps in SIMPLE Algorithm.

Application: In computational fluid dynamics (CFD), the SIMPLE algorithm is a widely used numerical procedure to solve the Navier–Stokes equations.

Video Links/Any other special information:

https://www.youtube.com/watch?v=DYTg71UACfI

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

https://www.youtube.com/watch?v=KR74TQesUoQ https://nptel.ac.in/courses/112/105/112105254/		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Turbulence models, mixing length model, Two equation (k-ε) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools **Experiential Learning:** Tutorial on Mesh Generation on Different Geometries with increasing complexities. **Application:**Applications in Fluid Mechanics, Heat Transfer related problems in Chemical Engineering Video Links/Any other special information: https://www.youtube.com/watch?v=nOLsa9WnhlU https://www.youtube.com/watch?v=zs-sDuoeTVA https://www.youtube.com/watch?v=yGUg3WV3QLE https://nptel.ac.in/courses/112/105/112105254/		

Course outcomes:	
CO1	Understand the concept of computational fluid dynamics and its application
CO2	Analyze the consistency, stability and convergence of various discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.
CO3	Apply finite difference and finite volume methods to various chemical engineering problems.
CO4	Analyze variations of SIMPLE schemes for incompressible flows and variations of Flux Splitting algorithms for compressible flows.
CO5	Evaluate the grid sensitivity and analyse the accuracy of a numerical solution.

Text Books:	
1	Versteeg, H. K., &Malalasekera, W. (2007). *An introduction to computational fluid dynamics: the finite volume method*. Pearson education.
2	Muralidhar, K. and Sundararajan (Narosa), T. (2011). Computational Fluid Flow and Heat Transfer 2nd Edition.
Reference Books:	
1	Patankar, S.V. (2004). Numerical Heat Transfer and Fluid Flow. (Hemisphere

	Publishing Corporation).
2	Chung, T. J. (2002). *Computational fluid dynamics*. Cambridge university 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 (2 Nos.)		5X2=10
Journals/Progress notes		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	--	--	2	--	--	--	--	--	--	--
CO2	3	3	--	--	2	--	--	--	--	--	--	--
CO3	3	3	2	--	2	--	--	--	--	--	--	--
CO4	3	3	2	--	2	--	--	--	--	--	--	--
CO5	3	3	--	--	2	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	PROCESS ENGINEERING ECONOMICS	Semester	VII
Course Code	MVJ20CH742	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 study various phases in process design & development.

To determine cost involved in various processes.

Estimation of capital cost, alternative investments and replacement analysis.

To study direct, indirect expenses involved and profitability evaluation methods.

To study various financial statements, significance of financial ratios and cash flow diagram.

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

Process design development: Overall planning of a plant, Feasibility studies and Material & energy balance, Equipment sizing and selection, Analysis of Process flow sheet, P & I diagram, Plant layout and location, Factors affecting plant design.

Experiential Learning: Demonstrating P&ID, Plant location and its feasibility.

Applications: Factors to be considered for plant selection and location.

Video link / Additional online information:

https://www.youtube.com/watch?v=BzPTGWKLP7c

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

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

Cost analysis: Elements of project cost - cost information, Factors affecting investment & production cost, Estimation of capital investment, operation costs, project financing, Factors in capital investment, Estimation of working capital, cost index, taxes and insurance. **Time value of money**: Types of interests, Effective and nominal interest rates, present worth and discount.

Experiential Learning: Comparing different types of costs and their impact.

Applications: Able to understand the sequence of cost flow in any industry.

Finite Volume Method: It tends to be biased toward edges and one-dimensional physics.

Video Links/Any other special information:

https://www.youtube.com/watch?v=65PlvATnK1o

https://www.youtube.com/watch?v=nutIE5uGi5c&list=PLbMVogVj5nJS8aivkHJC_5KMvYj7wMcvk&index=32

Module-3	RBT Level: L1, L2, L3	8 Hours
Depreciation & taxes: Types of Depreciation and calculation methods. **Profitability:** Profitability, Cash flow diagrams, break even analysis, measures of process profitability, methods of evaluation of profitability - Rate of return on investment, Discounted cash flow based on full-life performance, Net present worth, Capitalized costs, Payout period, Simplified model for economic analysis of process design. **Experiential Learning:**Case study on economic analysis of a process design. **Applications:** Detailed techno-economic analysis of any chemical process. **Video Links/Any other special information:** 1 https://www.youtube.com/watch?v=1tOrhhjVjH0 https://www.youtube.com/watch?v=nutIE5uGi5c&list=PLbMVogVj5nJS8aivkHJC_5KMvYj7wMcvk&index=32		
Module-4	**RBT Level: L1, L2, L3**	**8 Hours**
Replacements: Theory of replacements, causes for replacements types of replacements. **Alternative investments:** Theory of alternative investments and causes for the same. **Optimum design and design strategy:** Procedures for determining optimum conditions- Single and multi-variable procedures, Significance of breakeven chart for optimum analysis, Optimum rate of production- concept of minimum cost of the product, maximum cost of the product and case of maximum profit **Experiential Learning::** Case study on optimum conditions determination using any tool. **Applications:** The application of optimum design and its strategy for process industries. **Video Links/Any other special information:** https://www.youtube.com/watch?v=wW9mejsHLvg https://www.youtube.com/watch?v=nutIE5uGi5c&list=PLbMVogVj5nJS8aivkHJC_5KMvYj7wMcvk&index=32		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
Financial statements: Introduction to financial statements, Cash flow diagrams, balance sheet and Break-even analysis. **Equipment cost and design report:** Heat transfer equipment costs, Mass transfer equipment costs, Plate and packet towers, dryers, cost estimation for reactor equipment components, cost of piping. **Design report:** Introduction to design of reports. Types of reports, Organization of report and purpose of report. **Experiential Learning:**Cost-estimation of any simple chemical equipment.		

Applications: Estimating the best cost with economic considerations for chemical process industries. **Video Links/Any other special information:** https://www.youtube.com/watch?v=80vu5lxOluQ https://www.youtube.com/watch?v=Om24w_EcWIE	
Course outcomes:	
CO1	Discuss basic aspects of process development and economics, process flow sheet.
CO2	Explain the concepts of elements of project costing and time value of money.
CO3	Calculate various cost elements and draw cash flow diagrams and economic analysis of process design.
CO4	Explain theory of replacements and alternative investments and determine optimum cost and rate of product.
CO5	Discuss financial statements, breakeven analysis and prepare design reports, and determine equipment and piping costs.
Text Books:	
1	Banga, T.R. and Sharma, S.C. (1999). Industrial Organization & Engineering Economics 22nd Edition. (Khanna Publishers).
2	Peters, M. S., Timmerhaus, K. D., & West, R. E. (2003). *Plant design and economics for chemical engineers* (Vol. 4). New York: McGraw-Hill.
Reference Books:	
1	Happel, J. and Jordan, D.J. Chemical Process Economics. (Marcal Dekker Inc.) ISBN: 0824761553, 2005.
2	Web Link and Video Lectures: https://nptel.ac.in/courses/103103039/

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	--	--	--	--	--	--	--	--	--
CO2	3	3	3	--	--	--	--	--	--	--	--	--
CO3	3	3	3	--	--	--	--	--	--	--	--	--
CO4	3	3	3	--	--	--	--	--	--	--	--	--
CO5	3	3	3	--	--	--	--	--	--	2	2	2

High-3, Medium-2, Low-1

Course Title	PROCESS INTENSIFICATION	Semester	VI
Course Code	MVJ20CH743	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:

- To provide an understanding of the concept of Process Intensification.
-

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification.

Experiential Learning: Demonstration on Chemical reactor heat exchangers

Applications: Students will be able to understand the importance of chemical reactor heat exchanger, most chemical reactions are faster at higher temperatures and heat exchangers are frequently used to provide the heat necessary to increase the temperature of the reaction.

Video Links/Any other special information (Papers):

https://nptel.ac.in/content/storage2/courses/103103029/pdf/mod1.pdf

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

Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Micro channel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes.

Experiential Learning: Demonstration on Spiral heat exchanger

Applications: Students will be able to understand the various industrial process applications of spiral heat exchanger because they can perform tasks such as: pasteurization, digester heating, heat recovery, pre-heating and effluent cooling.

Video Links/Any other special information (Papers):

https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-me43/

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

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation reactors, Nusselt flow model and mass transfer, The Rotating electrolytic Cell, Electrostatic fields, Sono crystallization, Supercritical fluids.

Experiential Learning: Demonstration on Sonocrystallization.

Applications: Students can understand the modern technique which involves the application of ultrasound energy to control the nucleation and crystal growth of a crystallization process.

Video Links/Any other special information (Papers):

https://nptel.ac.in/content/storage2/courses/103105060/Sde_pdf/Module-10.pdf

Course outcomes:

CO1	Explain the concept of Process Intensification and the methodologies for PI.
CO2	Explain the benefits of PI in the process industries.
CO3	Explain the operating principles of a number of intensified technologies.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Solve process challenges using intensification technologies
Text Books:	
1	Reay, D. (2005). Re-Engineering the Chemical Processing Plant: Process Intensification, Andrzej Stankiewicz, Jacob A. Moulijn (Eds.), Marcel Dekker, Inc (2003), p. 529, $165, ISBN: 0 8247 4302 4.
2	Stankiewicz, A., Van Gerven, T., &Stefanidis, G. (2019). The fundamentals of process intensification. John Wiley & Sons.
Reference Books:	
1	Reay, D., Ramshaw, C., & Harvey, A. (2013). Process Intensification: Engineering for efficiency, sustainability and flexibility. Butterworth-Heinemann.
2	Boodhoo, K., & Harvey, A. (Eds.). (2013). Process intensification technologies for green chemistry: engineering solutions for sustainable chemical processing. John Wiley & Sons.

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	2	--	--	--	--	--	--	--	--	--	--	--
CO2	3	2	2	--	--	2	2	--	--	--	2	3
CO3	3	2	2	--	--	2	2	--	--	--	2	3
CO4	3	2	2	--	--	2	2	--	--	--	2	3
CO5	3	2	--	--	--	2	2	--	--	--	2	3

High-3, Medium-2, Low-1

Course Title	MULTI-COMPONENT DISTILLATION	Semester	VII
Course Code	MVJ20CH744	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:

- Understand the concept of distillation applicable to multi-component systems.
-

points (Azeotropic mixture).

Applications: To separate a multicomponent mixture with n components into n pure products through distillation, a sequence of distillation columns referred to as a distillation configuration is usually required.

Video Links/Any other special information (Papers):

https://www.osti.gov/servlets/purl/1433494

https://link.springer.com/article/10.1007%2Fs11814-007-0002-1

https://aiche.onlinelibrary.wiley.com/doi/abs/10.1002/aic.690340411

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

Thermodynamic Property Evaluation: Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

Experiential Learning: Demonstration of multiphase reactor which aims at improving chemical reaction by simultaneous product removal and evaluation of thermodynamic properties.

Applications: There are various reactions that satisfy this criterion, but this technology is applied only for etherification, esterification, and alkylation (synthesis of ethylbenzene or cumene) on an industrial scale.

Video Links/Any other special information (Papers):

https://www.nist.gov/publications/critical-evaluation-thermodynamic-properties-halobenzoic-acids-through-consistency

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

Minimum Reflux Ratio for MCD System: General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components -Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for multi component distillation – Underwood method – Colburn method.

Experiential Learning: Studies on Evaluation of Optimum Reflux ratio using Underwood method.

Applications: Number of numerical methods have been developed. One of the most powerful techniques is the Underwood method and Colburn method to evaluate minimum and optimum reflux ratio for Multi component systems.

Video Links/Any other special information (Papers):

https://cheguide.com/shortcut_distillation.html

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

Various Types of MCD Columns: Design of sieve, bubble cap, valve trays and structured packing

columns for multi component distillation – computation of plate efficiencies.

Experiential Learning: Demonstration of various types of trays and packing materials used for designing Multi component distillation columns.

Applications: Helps to understand how to calculate the plate efficiencies and also design parameters 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://aiche.onlinelibrary.wiley.com/doi/abs/10.1002/aic.690170520#:~:text=In%20the%20design%20of%20the,the%20liquid%20leaving%20the%20plate

https://nitsri.ac.in/Department/Chemical%20Engineering/Distillation_Notes-PartIV.pdf

http://facstaff.cbu.edu/rprice/lectures/distill6.html

Course outcomes:	
CO1	Explain the concept of Phase equilibria in Multi component systems and its principles
CO2	Explain the various distillation processes and Phase behavior at constant pressure
CO3	Explain the evaluation of thermodynamic properties for multi component distillation.
CO4	Apply numerical methods for determining the minimum reflux ratio for MCD Systems.
CO5	Explain the various types of MCD Columns.

Text Books:	
1	Holland, C. D. (1981). Fundamentals of multicomponent distillation (Vol. 543). New York: McGraw-Hill.
2	Billet, R. (1979). Distillation engineering.
Reference Books:	
1	King, C. J. (2013). Separation processes. Courier Corporation.
2	Holland, C. D. (1966). Unsteady State Processes with Applications in Multicomponent Distillation. 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
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	2	--	--	--	--	--	--	--	--	--	--
CO2	3	2	--	--	--	--	--	--	--	--	--	--
CO3	3	--	--	--	--	--	--	--	--	--	--	--
CO4	3	2	--	--	--	--	--	--	--	--	--	--
CO5	3	2	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	GREEN TECHNOLOGY	Semester	VII
Course Code	MVJ20CH751	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:

- Learn the tools of green technology
-

geothermal power plants case studies and environmental impact assessment.

Experiential Learning: Demonstration to Learn how to assess the solar energy potential of a site using a pyranometer.

Demonstration on working of Solar Water Heater.

Applications: Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies. solar radiation measurements are of primary interest for applications like site-specific solar resource assessments, PV performance evaluation, solar resource forecasting, and so on.

Video Links:https://www.energy.gov/eere/solar/solar-radiation-basics

https://www.hukseflux.com/applications/solar-energy-pv-system-performance-monitoring/how-to-measure-solar-radiation

Module-3	RBT Level: L1, L2	8 Hours

Energy from biomass (bio-energy): Introduction, biomass conversion technologies, wet Processes, dry Processes, biogas generation, factors affecting bio digestion, types of biogas plants (KVIC model & Janata model), selection of site for biogas plant Bio Energy (Thermal Conversion): Methods for obtaining energy from biomass, thermal gasification of biomass, classification of biomass gasifiers, chemistry of the gasification process, applications of the gasifiers.

Experiential Learning: Demonstration of an experiment to produce biogas from various sources of biomass using Bio methanation.

Applications: Biomass is renewable organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes

Video Links:https://www.ovoenergy.com/guides/energy-sources/bio-fuels.html

https://www.nrel.gov/research/re-biomass.html

Module-4	RBT Level: L1, L2	8 Hours

Wind Energy: Introduction, basic components of WECS (Wind Energy Conversion system), classification of WEC systems, types of wind machines (Wind Energy Collectors), horizontal-axial machines and vertical axis machines. Ocean Thermal Energy:

OTEC-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, the closed or Anderson, OTEC cycle, **Hybrid cycle Energy from Tides:** Basic principles of tidal power, components of tidal power plants, operation methods of utilization of tidal energy, advantages and limitations of tidal power generation

Experiential Learning: Demonstration of wind turbines and case studies on Wind energy.

Applications: OTEC is potentially capable to produce more energy than conventional tidal, wave, and wind energy combined. The OTEC technologies, in principle, is to turn warm surface water into steam, or used to heat another fluid into vapour and spins a turbine to produce electricity.

Video Links:

www.emsd.gov.hk/energyland/en/energy/renewable/otec.html#:~:text=It%20is%20believed%20that%20OTEC,a%20turbine%20to%20produce%20electricity.

http://otecokinawa.com/en/OTEC/index.html

Module-5	RBT Level: L1, L2	8 Hours

Hydrogen as a Fuel: Introduction, methods of hydrogen production (principles only), storage transportation, utilization of hydrogen gas, hydrogen as alternative fuel for motor vehicle, safety and management, hydrogen technology development in India.

Application of Green Technology: Electronic waste management, bioprocesses, green composite materials, green construction technology Sustainability of industrial waste management: Case studies on cement industry, iron and steel industry, petroleum sectors, marble and granite industry, sugar industry

Experiential Learning: Demonstrate an experiment for production of hydrogen by downward displacement setup as a project in laboratory.

Applications: The use of hydrogen greatly reduces pollution. When hydrogen is combined with oxygen in a fuel cell, energy in the form of electricity is produced. This electricity can be used to power vehicles, as a heat source and for many other uses.

Video Links: https://www.cesa.org/wp-content/uploads/CESA-Lipman-H2-prod-storage-050311.pdf

https://en.wikipedia.org/wiki/Hydrogen_production

Course outcomes:

CO1	Recall the fundamentals of various forms of energy
CO2	Explain the principles of various forms of renewable energy
CO3	Apply the concept of zero waste, atom economy for waste management
CO4	Create a waste management plan incorporating tools of green technology in various industries
CO5	Explain the various methods for Hydrogen production, storage, transportation and utilization.

Text Books:	
1	Rai, G. D. (2004). Non-conventional energy resources. *Khpu Khanna, India*, *369*, 331-337.
2	Twidell, J., & Weir, T. (2015). *Renewable energy resources*. Routledge.
Reference Books:	
1	Boyle, G. (1996). *Renewable energy: power for a sustainable future* (Vol. 2). Oxford University Press.
2	Everett, R., Boyle, G., Peake, S., & Ramage, J. (2012). *Energy systems and sustainability: power for a sustainable future*. Oxford Univerity 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
Mini Projects/ Case studies- 2 Nos.		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	1	--	--	--	1	2	1	--	1	--	--
CO2	2	1	--	--	--	1	2	--	--	--	--	--
CO3	1	2	1	2	1	3	3	3	2	1	1	--
CO4	2	1	2	2	--	--	2	--	--	1	3	--
CO5	2	1	--	--	--	1	2	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	AIR POLLUTION AND CONTROL	Semester	VII
Course Code	MVJ20CH752	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 knowledge on the principles and design of control of indoor/ particulate / gaseous air pollutant and its emerging trends.

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

INTRODUCTION: Structure and composition of Atmosphere – History of Air pollution and episodes, Causes of air pollution and types, Introduction to meteorology toxicology and transport of air pollution, Sources and classification of air pollutants - Effects of air pollutants on human health, vegetation & animals, Materials & Structures – Effects of air Pollutants on the atmosphere, Soil & Water bodies – Long- term effects on the planet – Global Climate Change, Ozone Holes – Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories.

Experiential Learning: Demonstrate the importance of controlling air pollution and emission standard.

Applications: Air quality can be measured based on the emission standard in different locations.

Video Links:

NPTEL: https://www.youtube.com/watch?v=XHy1eqJqzKk

NPTEL WEB CONTENT: https://nptel.ac.in/courses/105/102/105102089/

MIT LECTURE NOTE: https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-335-experimental-atmospheric-chemistry-fall-2014/lecture-notes/

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

AIR POLLUTION MONITORING AND MODELING: Physicochemical processes governing the spread of pollutants from point, non-point, line, and area sources; Generation, transport and decay of air pollutants; Mathematical Modelling of dynamics of pollutants, Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants - Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport & Dispersion of Air

Pollutants – Modelling Techniques – Air Sampling and monitoring methods.

Experiential Learning: Demonstrate the modelling technique and air sampling methods.

Applications: Dispersion of air pollutant from chimney, in the air can be measured by wind profile and stack plume patterns.

Video Links:

NPTEL WEB CONTENT: https://nptel.ac.in/courses/105/102/105102089/

NPTEL COURSE: https://onlinecourses.nptel.ac.in/noc20_ch01/preview

https://nptel.ac.in/courses/105/104/105104099/

https://www.youtube.com/watch?v=9uqQ6xaETZg

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

CONTROL OF PARTICULATE CONTAMINANTS: Factors affecting Selection of Control Equipment - Gas Particle Interaction, Working principle, Design and performance equations of Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators - Operational Considerations -Process Control and Monitoring - Costing of APC equipment - Case studies for stationary and mobile sources.

Experiential Learning: Demonstrate different device available for controlling particulate matter.

Applications: Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators are used for controlling particulate matter in industry.

Video Links:

https://nptel.ac.in/courses/105/104/105104099/

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

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

CONTROL OF GASEOUS CONTAMINANTS: Control Equipment, Factors affecting Selection of Control Equipment - Working principle, Design operation and performance of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters - Process control and Monitoring - Operational Considerations -Costing of APC Equipment - Case studies for stationary and mobile sources.

Experiential Learning: Demonstrate different device available for controlling gaseous contaminant.

Applications: Adsorption, condensation, Incineration, Bio scrubbers, Bio filters are implemented in the industries for controlling gaseous pollutant.

Video Links:

https://nptel.ac.in/courses/105/104/105104099/

https://www.youtube.com/watch?v=sR0U9h_kMTw https://www.youtube.com/watch?v=sw_GjLZ89aY		
Module-5	**RBT Level: L1, L2, L3**	**8 Hours**
AUTOMOBILE AND NOISE POLLUTION: Vehicular Pollution: Automobile emission - Types of emissions - Exhaust emissions, evaporative emissions, crank-case emissions- Prevention and control of vehicular pollution. Noise Pollution: Sources and Effects of Noise Pollution - Measurement - Standards - Control and Preventive measures. Sources types and control of indoor air pollutants, sick building syndrome types - Radon Pollution and its control. Air pollution legislation and regulations. Case studies of a few industrial pollution control systems. **Experiential Learning:** Demonstrate the important of controlling automobile and noise pollution. **Applications:** Air pollution legislation and regulation should be strictly followed to control the air pollution. **Video Links:** 1. https://www.youtube.com/watch?v=tsvBXUQWAOU 2. https://www.youtube.com/watch?v=LyaVQBfVq7w 3. https://nptel.ac.in/courses/103/107/103107084/		

Course outcomes:	
CO1	Explain the fundamentals of Atmospheric pollution and discuss the effects of Process Air Pollution.
CO2	Discuss Air pollution monitoring and Mathematical modeling of dynamics of pollutants.
CO3	Explain the control of particulate contaminants
CO4	Explain the control of gaseous contaminants
CO5	Discuss the automobile and noise pollution and the types of automobile emissions

Text Books:	
1	Wang, L. K., Pereira, N. C., & Hung, Y. T. (Eds.). (2004). *Air pollution control engineering* (Vol. 1, pp. 157-165). Totowa, NJ: Humana press.
2	De Nevers, N. (2010). *Air pollution control engineering*. Waveland press.
Reference Books:	

1	David, H.F. Liu, Bela G. Liptak. (2000).*Air Pollution*, Lewis Publishers.
2	Anjaneyulu, Y. (2002).*Air Pollution & Control Technologies,* Allied Publishers (P) Ltd. India.
3	Vallero, D. (2014). *Fundamentals of air pollution*. Academic press.

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	--	--	--	--	3	3	3	--	--	--	--
CO2	2	2	--	--	--	3	3	3	--	--	--	--
CO3	2	2	--	--	--	3	3	3	--	--	--	--
CO4	3	2	--	--	--	3	3	3	--	--	--	--
CO5	2	--	--	--	--	3	3	3	--	--	--	--

Course Title	NANOSCIENCE & NANOTECHNOLOGY	Semester	VII
Course Code	MVJ20CH753	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:

- Understand the behavior of various smart materials and its applications.
-

limitations

Experiential 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 Links/Any other special information (Papers):

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	8 Hours

Nanomaterials: Synthesis and Characterization: Introduction, basic nanostructures: CNTs, nanowires, nanocones; quantum dots, quantum dot nanocrystals, ultra-nanocrystalline diamond, diamondoids, nanocomposites, thin films, nanofoams, nanoclusters, smart nanostructures.

Characterization of Nano materials: Microscopy-Scanning tunnelling 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.

Experiential 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: Understand various nano materials, synthesis methods. Characterization of prepared nanomaterial is required to determine the surface area, particle size and quantities based on its mass.

Video Links/Any other special information (Papers):

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	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 Epitaxy (MBE). Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Self-Assembly

Experiential 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 Links/Any other special information(Papers):

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	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-sensitised 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.

Experiential 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 Links/Any other special information(Papers):

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

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

Course outcomes:

CO1	Understand the concept of nano and its opportunities in various fields
CO2	Understand the basic science of basic nano technology
CO3	Identify various nano materials and recall nano materials synthesis,

	characterization techniques
CO4	Identify various nano manufacturing techniques.
CO5	Understand the applications of Nano technology in various fields.

Text Books:	
1	Varghese, P. I., & Pradeep, T. (2003). A textbook of nanoscience and nanotechnology. Tata McGraw-Hill Education.
2	Fiiipponi, L., & Sutherland, D. (Eds.). (2012). Nanotechnologies: principles, applications, implications and hands-on activities: A compendium for educators. European Union, Directorate General for Research and Innovation.
3	Bandyopadhyay. K. Nano Materials (2007). New Age International Publishers; First edition.
Reference Books:	
1	Callister, W. D. (2007). An introduction: material science and engineering. John Wiley and Sons Inc.
2	Hari, S.N. Nano-structured Materials and Nanotechnology, (2002), Gulf Professional Publishing, Academic 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 – 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	--	--	--	--	--	--	--	--	--	--
CO2	--	3	3	2	--	--	--	--	--	--	--	--
CO3	--	3	1	3	--	--	--	--	--	--	--	--
CO4	--	--	3	--	--	--	--	--	--	--	--	--
CO5	--	3	1	2	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Course Title	SOLID WASTE MANAGEMENT	Semester	VII
Course Code	MVJ20CH754	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 hrs

Course objective is to:

- Understand solid waste management from an environmental public health perspective.
-

Video link / Additional online information: https://nptel.ac.in/courses/105/103/105103205/		
Module-3	**RBT Levels: L1, L2, L3**	**8 Hours**
PROCESSING TECHNIQUES: Mechanical volume reduction. Thermal volume reduction. Component separation. Land filling and land forming. Deep well injection. **Laboratory Sessions/ Experimental learning:** Landfill in a Bottle **Applications:** Students will understand how household/college waste breaks down in a landfill, recognize the impact of waste on the environment **Video link / Additional online information:** https://nptel.ac.in/courses/120/108/120108005/		
Module-4	**RBT Levels: L1, L2, L3**	**8 Hours**
MATERIAL RECOVERY: Mechanical size alteration. Electromagnetic separation. Drying and dewatering. Other material recovery systems. Recovery of biological conversion products. Recovery of thermal conversion products. **ENERGY RECOVERY**: Energy recovery systems and efficiency factors. Determination of output and efficiency. Details of energy recovery systems. Combustion incineration and heat recovery. Gasification and pyrolysis. Refuse derived fuels (RDF). **Laboratory Sessions/ Experimental learning:** Safe combustion reaction **Applications:** Students learn about chemistry, chemical reactions & energy by studying combustion reactions **Video link / Additional online information:** http://cpheeo.gov.in/upload/uploadfiles/files/chap15(1).pdf		
Module-5	**RBT Levels: L1, L2, L3**	**8 Hours**
HAZARDOUS WASTES: Classification. Origin and reduction at source. Collection and handling. Management issues and planning methods. Environmental Acts. **CASE STUDIES:** Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, radioactive and e-waste generation units. **Laboratory Sessions/ Experimental learning:** Minimizing the hazardous 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 link / Additional online information:** https://nptel.ac.in/courses/105/106/105106056/		

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**
Mini Projects/ Case studies - 3Nos.		**3X2=6**
Semester End Examination	**SEE (50)**	**50**
	Total	**100**

Course Outcomes:	
CO1	Explain the physical and chemical characteristics of solid waste and Interpret the various techniques involved in reduction of solid waste.
CO2	Explain the various handling, storage, processing, collection, transfer & transport techniques involved in solid waste management
CO3	Explain the various handling and processing techniques involved in solid waste management.
CO4	Demonstrate the different techniques involved in material and energy recovery from solid waste
CO5	Explain various techniques to handle hazardous waste and outline the case study on solid waste management with respect to various chemical industries.

Text Books:	
1	George Tchobanoglous et al., Integrated Solid Waste Management,2ndedn, McGraw Hill & Co, 1993.
2	Dutta et al. Industrial Solid Waste Management and Land Filling Practice, Narosa Publishing House, 1999
Reference Books:	
1	Sastry C.A. et al, Waste Treatment Plants, Narosa Publishing House, 1995.
2	Lagrega, Hazardous Waste Management, McGraw Hill, 1994
3	Lagrega, Hazardous Waste Management, McGraw Hill, 1994

4	Web Link and Video Lectures: https://nptel.ac.in/courses/120108005/ https://nptel.ac.in/courses/105/103/105103205/ https://nptel.ac.in/courses/105/106/105106056/ https://nptel.ac.in/courses/105/105/105105160/

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

High-3, Medium-2, Low-1

Course Title	PROCESS CONTROL LAB	Semester	VII
Course Code	MVJ20CHL76	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 process control concepts studied in theory.
-

15	Characteristics of flapper nozzle system	L1, L2, L3, L4	3

Course outcomes:	
CO1	Explain properties of particulate solids, handling and mixing of solid particles.
CO2	Analyse principles and different types of size reduction equipment's like crushers, grinders etc.
CO3	Evaluate the effectiveness of screening, filtration, sedimentation, of solids etc.
CO4	Evaluate energy requirements in solids handling, agitation and mixing, solid conveying and storage.
CO5	Conduct experiments on some of the basic unit operations such as separation size reduction.

Scheme of Evaluation		
Details		**Marks**
Regular Lab Work	**CIE (50)**	**20**
Record Writing		**5**
Lab Test (minimum 2 tests shall be conducted for 15 marks and average of two will be taken)		**15**
Viva		**10**
Write up	**SEE (50)**	**10**
Conduction		**20**
Analysis of results		**10**
Viva		**10**
Total		**100**

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	0	0	0	0	0	0	0	0	0
CO2	2	2	2	2	0	0	0	0	0	0	0	0
CO3	2	2	2	2	0	0	0	0	0	0	0	0
CO4	2	2	2	0	0	0	0	0	0	0	0	0
CO5	2	2	2	2	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	CHEMICAL PROCESS SIMULATION LAB	Semester	VII
Course Code	MVJ20CHL77	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 commercial process simulator for solving chemical process in chemical engineering operations.

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.	Introduction to suggested software available (flow sheeting)	L1, L2, L3, L4	3
2.	2. Simulation of Shell and Tube Heat Exchanger	L1, L2, L3, L4	3
3.	3. Simulation of Centrifugal Pump/Compressor	L1, L2, L3, L4	3
4.	4. Simulation of Flash drum/Separator	L1, L2, L3, L4	3
5.	5. Simulation of single stream gas heater/cooler	L1, L2, L3, L4	3
6.	6. Simulation of CSTR for liquid phase reaction	L1, L2, L3, L4	3
7.	7. Simulation of Distillation Column	L1, L2, L3, L4	3
8.	8. Mixing of ideal liquid streams	L1, L2, L3, L4	3
9.	9. Generation of VLE data of binary component system	L1, L2, L3, L4	3
10.	10. Determination of equilibrium conversion of reversible reactions	L1, L2, L3, L4	3
11.	11. Material balance on reactor based on yield/conversion data	L1, L2, L3, L4	3
12.	12. Process simulation study involving mixing, reactor, distillation, heat exchanger for any of the following: a) Ethylene Glycol from Ethylene oxide b) Atmospheric distillation of crude oil c) Propylene Glycol from Propylene oxide	L1, L2, L3, L4	3

	d) Aromatic stripper with recycle stream (Benzene, Toluene, Xylene) e) Styrene from Ethyl Benzene		

Note:

- Minimum of 10 experiments are to be conducted and all 10 experiments are to included for practical examination.

Course outcomes:

CO1	Distinguish simulation from design of equipment.
CO2	Explain simulation of unit operations used in various chemical engineering operations.
CO3	Use simulation tools to verify and analyze chemical processes, and to determine optimal solutions.
CO4	Understand the application of simulation and data processing in chemical engineering
CO5	Understand process simulation study of industrially important chemical processes

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	--	--	--	--	--	--	--
CO2	3	3	3	--	3	--	--	--	--	--	--	1
CO3	3	3	3	--	3	--	--	--	--	--	--	2
CO4	3	3	3	--	3	--	--	--	--	--	--	2
CO5	3	3	3	--	3	--	--	--	--	--	--	2

High-3, Medium-2, Low-1

Course Title	PROJECT PHASE – I	Semester	VII
Course Code	MVJ20CHP78	CIE	50
Total No. of Contact Hours	60 L : T : P :: 0 : 0 : 60	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	2	Exam. Duration	3 Hours

Course Objective:

- To support independent learning.
-

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

Course Title	PROJECT PHASE – II	Semester	VIII
Course Code	MVJ20CHP83	CIE	50
Total No. of Contact Hours	240 L : T : P :: 0 : 0 : 240	SEE	50
No. of Contact Hours/week	16	Total	100
Credits	8	Exam. Duration	3 Hours

Course Objective:

- To support independent learning.
-

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

Course Title	INTERNSHIP	Semester	VIII
Course Code	MVJ20CHI84	CIE	50
Total No. of Contact Hours	Industrial Oriented	SEE	50
No. of Contact Hours/week	-	Total	100
Credits	3	Exam. Duration	3 Hours

Course Objective:

- To get the field exposure and experience
-

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

Course Title	SEMINAR	Semester	VIII
Course Code	MVJ20CHS85	CIE	50
Total No. of Contact Hours	30 L:T:P::0:0:30	SEE	50
No. of Contact Hours/week	2	Total	100
Credits	1	Exam. Duration	3 Hours

Course Objective:

- To inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Seminar: Each student, under the guidance of a Faculty, is required to choose, preferably, a recent topic of his/her interest relevant to the course of specialization. Carryout literature survey; organize the Course topics in a systematic order.

-

be conducted by a panel of examiners consisting of seminar supervisor, a senior faculty from the department and head of the department.

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

Course Title	CERTIFICATION	Semester	VIII
Course Code	MVJ20CHC86	CIE	-
Total No. of Contact Hours	-	SEE	-
No. of Contact Hours/week	-	Total	-
Credits	2	Exam. Duration	3 Hours

Course Objective:

- To inculcate self-learning enhance the skill in different field of Engineering

Certification: Each student, under the guidance of a Faculty, is required to undergo online certification course minimum of 30 hours (number of courses is not limited) preferably, a recent topic of his/her interest. Each student should submit the Course details and Qualification Certificates at the end of semester.

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

CO1	Develop knowledge in different fields of Engineering
CO2	Develop the skills to enable life-long learning.