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.
- Explain need of coordination between the manager and staff, the social responsibility of business and leadership.
- Explain the role and importance of the entrepreneur in economic development and the concepts of entrepreneurship.
- Discuss the importance of Small-Scale Industries and the related terms and problems involved.
- Explain project feasibility study and project appraisal and discuss project financing.

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

Management: Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art &Profession.

Planning: Nature, Importance and Purpose Of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making.

Laboratory Sessions/ Experimental learning

- Case study on decision making process in a Corporate. Applications
- Planning in engineering field.

Web Link and Video Lectures

- https://nptel.ac.in/courses/110/105/110105146/
- https://nptel.ac.in/courses/122/108/122108038/

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

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
- Effective communication in a corporate.

Web Link and Video Lectures

- https://nptel.ac.in/content/storage2/courses/122106031/slides/3_2s.pdf
- https://www.slideshare.net/100005130728571/27-nature-of-directing

Module-3	RBT Level: L1, L2	8 Hours

Social Responsibilities of Business: Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance.

Entrepreneurship: Definition of Entrepreneur, Importance of Entrepreneurship, concepts of Entrepreneurship, Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Intrapreneur – An Emerging Class, Comparison between Entrepreneur and Intrapreneur, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs and capacity building for Entrepreneurship.

Laboratory Sessions/ Experimental learning

- Case study of a startup. Application
- Social auditing in a software company

Web Link and Video Lectures

- https://nptel.ac.in/courses/110/106/110106141/
- https://nptel.ac.in/courses/127/105/127105007/

Module-4	RBT Level: L1, L2	8 Hours

Modern Small Business Enterprises: Role of Small Scale Industries, Concepts and

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.
- Application: Preparations of project

report. **Web Link and Video Lectures**

- https://www.projectmanager.com/project-scheduling
- https://kissflow.com/project/basics-of-project-scheduling/

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		2x2 = 4

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.
- Develop rate laws for heterogeneous reactions.
- Learn the gas-solid catalytic and non-catalytic reactors and gas-liquid reactors.
- Explain the extent of non-ideality in a reactor.

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

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

Experiential Learning: RTD studies in typical reactors using virtual labs.

Applications: To predict the exact behaviour of a vessel as a chemical reactor, RTD or stimulus response technique is used. The tracer technique, the most widely used method for the study of axial dispersion, is usually used in the form of: Pulse input. Step input.

Video Links:

http://www.umich.edu/~elements/fogler&gurmen/html/course/lectures/fourteen/index.htm

http://www.umich.edu/~essen/html/byconcept/chapter13.pdf

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

Introduction to Heterogeneous Systems: Rate equations, contacting patterns, Fluid-particle non catalytic reactions, URC model, Spherical particles of unchanging size, shrinking spherical particles, determination of rate controlling steps. **Fluid-Particle Reactors – Design:** Fluid-Fluid Non-Catalytic Reactions: Kinetic regimes for mass transfer and reaction; rate equations.

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.
- Apply mass transfer fundamentals to calculate mass transfer rates and design the mass transfer equipment.

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

Types of diffusion in fluids and solids. Measurement and calculations of diffusivities. Multi component diffusion. Mass transfer coefficients and their correlations. Theories of mass Transfer.

Inter phase mass transfer. Material balance for co-current, cross-current and counter-current operations. Concept of stages, cascades operation, NTU and HTU concepts.

Experiential Learning: Experimental determination of mass-transfer coefficients and area of dumped packing using alkanolamine solvents.

To verify Fick's law: Determination of mass transfer co-efficient.

Applications: It helps in understanding many practical applications like sintering to produce solid materials (powder metallurgy, production of ceramics). Catalyst design in chemical industry, elimination of toxic gases and deodorization of air, recovery of solvents.

Video Links/Any other special information (Papers):

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

https://www.intechopen.com/books/mass-transfer-advancement-in-process-modelling/mass-transfer-in-multiphase-systems

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

Humidification: General theory, Psychrometric chart. Adiabatic saturation temperature, Wet bulb temperature, Concepts in humidification dehumidification.

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.
- Study of DLVO theory; adsorption at interfaces; characterization of solid surfaces.
- Understand the applications in detergents, personal-care products, pharmaceuticals, nanotechnology, and food, textile, paint and petroleum industries

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

Colloidal Materials: Introduction, The colloidal state and classification, Importance of colloids, Properties and application of colloid systems, surface properties, Colloidal dispersion, origin of charge on colloidal particles, preparation & characterization of colloidal particles.

Experiential learning: Demonstration on preparation & characterization of colloidal particles.

Application: Adsorption of pollutants on the charged surface.

Video link / Additional online information:

https://www.youtube.com/watch?v=lLknI3374A8&ab_channel=BhavikRana

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

https://nptel.ac.in/content/storage2/courses/103104045/pdf_version/lecture1.pdf

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

Surfactants: Surfactants type (Anionic, cationic, Zwitter ionic, Gemini and non-ionic). Biosurfactant, Theory of surfactants. CMC. Kraft temperature. Phase behavior of cone surfactant systems, surfactant geometry, bilayers, vesicles and liquid crystals, and packing. Emulsions, Micro emulsions & Gels. Intermolecular Forces, Van-der-waals

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.
- Enable the students to manipulate microbes for improvement.
- Learn the production of important products through fermentation.

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

Introduction to Fermentation technology: Fermentation industry growth prospects, general requirements of fermentation processes, range of fermentation processes, parts of a fermentation process, upstream and downstream processing, aerobic and anaerobic fermentation, solid state and submerged fermentation.

Microbial growth kinetics: Major types of organisms used in fermentation. Microbial growth kinetics, Batch culture, Continuous Culture, Fed Batch culture.

Experiential Learning: To study kinetics of growth under batch conditions.

Applications: Fermentation is used for the commercial production of materials required for the development of drugs, diagnostic kits, drug delivery vehicles and medical devices.

Video link / Additional online information:

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

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

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

Isolation, preservation and improvement of industrially important microorganisms: Isolation of industrially important microorganisms, preservation of industrially important microorganism, improvement of industrial microorganism, media for industrial fermentations – media formulation, Development of inoculum for industrial fermentations.

Experiential learning: To isolate and count the microorganisms found in a sample by

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.
- Carry out experiment and make observations for various parameters.
- Study and use various reactors for determining rate constant and conversion.
- Evaluate the data and compare with reported literature.

Sl No	Experiment Name	RBT Level	Hours
1.	Interpretation of isothermal batch reactor	L1, L2, L3, L4	3
2.	Execution of Isothermal plug flow reactor.	L1, L2, L3, L4	3
3.	Performance of an isothermal mixed flow reactor.	L1, L2, L3, L4	3
4.	Performance of an semi batch reactor	L1, L2, L3, L4	3
5.	Degradation kinetics of dye in a photochemical reactor.	L1, L2, L3, L4	3
6.	Enzyme catalysed reaction	L1, L2, L3, L4	3
7.	Performance of an adiabatic batch reactor.	L1, L2, L3, L4	3
8.	Performance of an Packed bed reactor.	L1, L2, L3, L4	3
9.	RTD studies in Tubular reactor	L1, L2, L3, L4	3
10.	Effect of temperature on rate of reaction.	L1, L2, L3, L4	3
11.	Biochemical reaction in batch studies.	L1, L2, L3, L4	3
12.	Performing enzyme catalysed reactions in a batch reactor.	L1, L2, L3, L4	3
13.	RTD Studies in mixed flow reactor.	L1, L2, L3, L4	3
14.	Degradation kinetics of dye in a sonochemical reactor.	L1, L2, L3, L4	3
15.	Physico-chemical properties of a catalyst.	L1, L2, L3, L4	3

Course outcomes:

CO1	Experimentally verify the principles and working of reactors studied in theory.
CO2	Carry out experiment and make observations for various parameters.

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.
- Carry out experiment and make observations for various heat transfer equipment.
- Study the effect of U, h_i and h_o in design of equipment.
- Evaluate the performance characteristic for different heat transfer cases.

Sl No	Experiment Name	RBT Level	Hours
1	Bare tube heat exchanger	L-1, L-2, L3, L4	3
2	vertical shell and tube heat exchanger (Condenser)	L-1, L-2, L3, L4	3
3	Horizontal Shell and tube Heat exchanger (Condenser)	L-1, L-2, L3, L4	3
4	Helical Coil Heat exchanger	L-1, L-2, L3, L4	3
5	Emissivity of grey surface	L-1, L-2, L3, L4	3
6	Heat transfer coefficients in a packed bed	L-1, L-2, L3, L4	3
7	Double pipe Heat exchanger	L-1, L-2, L3, L4	3
8	Heat transfer in a jacketed vessel	L-1, L-2, L3, L4	3
9	Transient heat conduction	L-1, L-2, L3, L4	3
10	Heat Transfer in Fluidized Beds	L-1, L-2, L3, L4	3
11	Single effect evaporator	L-1, L-2, L3, L4	3
12	Spiral plate heat exchanger	L-1, L-2, L3, L4	3
13	Cross flow heat exchanger	L-1, L-2, L3, L4	3
14	Finned tube heat exchanger	L-1, L-2, L3, L4	3
15	Stefan Boltzman constant for radiation heat transfer	L-1, L-2, L3, L4	3
16	Experiment to verify Fourier's law	L-1, L-2, L3, L4	3

Course outcomes:

CO1	Experimentally verify the heat transfer 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.
- Carry out experiment and make observations for various parameters.
- Study and use various reactors for determining rate constant and conversion.
- Evaluate the data and compare with reported literature.
- The following experiments are to be carried out; the data are to be analyzed based on the theoretical aspects and recorded with comments.

Sl No	Experiment Name	RBT Level	Hours
1	Analysis of effluents for pH and alkalinity	L1, L2, L3 & L4	3
2	Determination of BOD	L1, L2, L3 & L4	3
3	Volatile, Fixed, Filterable and Dissolved solid analysis	L1, L2, L3 & L4	3
4	Analysis by ion selective electrode (any two anions)	L1, L2, L3 & L4	3
5	Measurement of particulate matter in Air	L1, L2, L3 & L4	3
6	Measurement of SO2 in air	L1, L2, L3 & L4	3
7	Analysis of exhaust by Orsat apparatus	L1, L2, L3 & L4	3
8	Determination of COD	L1, L2, L3 & L4	3
9	UV Spectrophotometer	L1, L2, L3 & L4	3
10	Determination of turbidity by turbidometer	L1, L2, L3 & L4	3
11	Flame photometer	L1, L2, L3 & L4	3
12	Dissolved Oxygen measurement	L1, L2, L3 & L4	3
13	Bomb calorimeter	L1, L2, L3 & L4	3
14	Viscometer	L1, L2, L3 & L4	3
15	Potentiometer titration	L1, L2, L3 & L4	3
16	Jar test apparatus	L1, L2, L3 & L4	3

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..
2	Mahajan, S. P. (1985). Pollution control in process industries. Tata McGraw-Hill Education.

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	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.
- Critically evaluate the science and policy ramifications of diverse energy portfolios on air and water quality, climate, weapons proliferation and societal stability.

Prerequisites: *Basic Science*

Module-1	RBT Level: L1, L2	3 Hours

Introduction to environmental studies, Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development. **Ecosystems (Structure and Function):** Forest, Desert, Rivers, Ocean. **Biodiversity:** Types, Hot spots; Threats and Conservation of biodiversity, Deforestation.

Video link:

- https://nptel.ac.in/courses/127/106/127106004/

Module-2	RBT Level: L1, L2	3 Hours

Advances in Energy Systems (Merits, Demerits, Global Status and Applications): Hydrogen, Solar, OTEC, Tidal and Wind. **Natural Resource Management (Concept and case-study):** Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Video link:

- https://nptel.ac.in/courses/121/106/121106014/

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/ • https://nptel.ac.in/courses/105/103/105103205/ • https://nptel.ac.in/courses/120/108/120108005/ https://nptel.ac.in/courses/105/105/105105160/		
Module-4	**RBT Level: L1, L2**	**3 Hours**
Global Environmental Concerns (Concept, policies, and case-studies): Global Warming ClimateChange;AcidRain;OzoneDepletion;Fluorideproblemindrinkingwater. **Video link:** • https://nptel.ac.in/courses/122/106/122106030/ • https://nptel.ac.in/courses/120108004/ • https://onlinecourses.nptel.ac.in/noc19_ge23/preview		
Module-5	**RBT Level: L1, L2**	**3 Hours**
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO 14001. **Video link:** • https://nptel.ac.in/courses/105/102/105102015/ • https://nptel.ac.in/courses/120/108/120108004/		
Course outcomes: On completion of the course, students would be able to		
CO1	Describe the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale.	

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.
- Facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
- Highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

Prerequisites: *Universal Human Values-I*

Module-1	**RBT Levels: L1, L2**	**6 Hours**

Review on Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education), Self-exploration as the Process for Value Education, Happiness and Prosperity – Current Scenario,

Value Education: Understanding Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, , Method to Fulfill the Basic Human Aspirations,

Practical Sessions: Sharing about Oneself (Tutorial 1), Exploring Human Consciousness (Tutorial 2), Exploring Natural Acceptance (Tutorial 3)

Video link:

- https://www.youtube.com/watch?v=85XCw8SU084
- https://www.youtube.com/watch?v=E1STJoXCXUU&list=PLWDeKF97v9SP_Kt6jqzA3pZ3yA7g_OAQz

- 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/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Module-3	RBT Levels: L1, L2	6 Hours

Review on Harmony in the Family – the Basic Unit of Human Interaction, Other Feelings, Justice in Human-to-Human Relationship, Understanding Harmony in the Society.

Harmony in the Family and Society: Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Vision for the Universal Human Order,

Practical Sessions: Exploring the Feeling of Trust (Tutorial 7), Exploring the Feeling of Respect (Tutorial 8), Exploring Systems to fulfill Human Goal (Tutorial 9).

Video link:

- https://www.youtube.com/watch?v=F2KVW4WNnS8
- https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

Module-4	RBT Levels: L1, L2	6 Hours

Harmony in the Nature/Existence: Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfillment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence.

Practical Sessions: Exploring the Four Orders of Nature (Tutorial 10), Exploring Co-existence in Existence (Tutorial 11).

Video link:

- https://www.youtube.com/watch?v=1HR-QB2mCF0

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

Course outcomes: On completion of the course, students would be able to

CO1	Explore themselves, get comfortable with each other and with the teacher
CO2	Enlist their desires and the desires are not vague.
CO3	Restate that the natural acceptance (intention) is always for living in harmony, only competence is lacking
CO4	Differentiate between the characteristics and activities of different orders and study the mutual fulfillment among them
CO5	Present sustainable solutions to the problems in society and nature

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