



**ಬಿ.ಎಂ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ**

(ಸ್ವಾಯತ್ತ ವಿದ್ಯಾ ಸಂಸ್ಥೆ)

**BMS COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU)

**CHEMICAL  
ENGINEERING**

Scheme & Syllabus

for

2013-2014

Core & Cluster Electives  
(III - VIII Semesters)

**ಬಿ.ಎಂ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ**

ಬುಲ್ ಟೆಂಪಲ್ ರಸ್ತೆ, ಬೆಂಗಳೂರು-560 019

**BMS COLLEGE OF ENGINEERING**

Bull Temple Road, Bangalore - 560 019





**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**INSTITUTE VISION**

Promoting Prosperity of mankind by augmenting human resource capital through quality Technical Education & Training

**INSTITUTE MISSION**

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

**DEPARTMENT VISION**

Be a globally recognized Chemical Engineering Department by imparting quality education.

**DEPARTMENT MISSION**

- High-quality education and experience to the budding Chemical Engineers.
- Chemical Engineering graduates to assume positions in process and other allied industries.
- Foster and encourage the pursuit of excellence in chemical science and engineering.
- Inculcate global research potential



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
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**Program Outcomes**

Students Acquire the following outcomes after attending the undergraduation Program in Chemical Engineering:

1. Able to apply the knowledge of mathematics, science, engineering fundamental, and an engineering specialization to the solution of Chemical engineering problems.
2. Ability to identify, formulate, research literature to analyse engineering problem for conclusion using first principles of mathematics, chemical science and engineering sciences.
3. Design chemical engineering processes that meet the specified needs with the appropriate consideration for the public health and safety, and the cultural, and environment considerations.
4. Conduct research, analysis and interpretation of data for synthesis of the information to provide valid conclusions.
5. Select and apply appropriate techniques, modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. Capable of applying broad reasoning by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of sustainable development.
8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices.
9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communicate effectively with the community and with the society at large and design documentation, make effective presentations, and give and receive clear instructions.
11. Demonstrate knowledge and understanding of the engineering and management principles and apply to work as a member in multidisciplinary environments.
12. Recognise the need for life-long learning in the broadest context of technology change.



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**Department of : Chemical Engineering**      **Program : BE**      **Semester: III**

Subject Code				Subject Title	Credits Hours/Week				Contact Hrs/wk	Marks		
					L	T	P	Total		CIE	SEE	Total
11	MA	3I	CT	Engineering Mathematics III	3	1	0	4	5	50	50	100
13	CH	4D	CTN	Chemical Technology	4	0	0	4	4	50	50	100
09	CH	3D	CFME	Fluid Mechanics	4	0	1	5	6	50	50	100
09	CY	3D	CEM	Technical Chemistry	3	0	1	4	5	50	50	100
13	CH	3D	CMOP	Mechanical Operations	4	0	1	5	6	50	50	100
09	CH	3D	CEQD	Chemical Process Equipment Drawing	2	0	1	3	4	50	50	100
<b>Total</b>								<b>25</b>	<b>30</b>	<b>300</b>	<b>300</b>	<b>600</b>

L-LectureHours/week; T-TutorialLectureHours/week; P-PracticalLectureHours/week.

CIE-ContinuousInternalEvaluation; SEE-SemesterEndExamination(of3Hours duration)

Forlaterentry MA3IMDIPtobetakeninadditiontoalltheabove

Dr.Samita Maitra  
HOD



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**Department of : Chemical Engineering**      **Program : BE**      **Semester: IV**

Subject Code				Subject Title	Credits Hours/Week				Contact Hrs/wk	Marks			
1	1	4	4		L	T	P	Total		CIE	SEE	Total	
					3	1	0	4					5
				A	T	Engineering Mathematics -IV							
				S	B	Material Science and Biomaterials							
				T	D	Process Engineering Thermo Dynamics							
				T	R	Process Heat Transfer							
				P	C	Chemical Process Principles and Calculation							
				M	A	Instrumental Methods of Analysis							
				<b>Total</b>						<b>25</b>	<b>300</b>	<b>300</b>	<b>600</b>

2

L-LectureHours/week; T-TutorialLectureHours/week; P-PracticalLectureHours/week.  
CIE-ContinuousInternalEvaluation; SEE-SemesterEndExamination(of3Hours duration)

Dr.Samita Maitra      Forlateralentry MA3IMDIPtobetakeninadditiontoalltheabove  
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Department of : Chemical Engineering										Program : BE			Semester: VI				
Subject Code		Subject Title								Credits Hours/Week			Contact Hrs/wk	Marks			
L	T	P	Total									CIE	SEE	Total			
13CH6DCRCR	2	Chemical Reaction Engineering-2								4	0	0	4	4	50	50	100
10CH6DCICP	C	Instrumentation and Process Control								4	0	1	5	6	50	50	100
10CH6DCMT	2	Mass Transfer-2								4	0	1	5	6	50	50	100
13CH6DCTRP	P	Transport Phenomena								4	0	0	4	4	50	50	100
Any One(Group C)																	
13CH6DELC	1	1. Applied Mathematics in Chemical Engg.								3	0	0	3	3	50	50	100
10CH6DELC	2	2. Operation Research.															
Any One(Group D)																	
14CH6DELD	1	1. Computer interface in Chemical Engineering								3	0	0	3	3	50	50	100
11CH6DELD	2	2. Interfacial Phenomenon and Related Separation Techniques															
<b>Total</b>													<b>24</b>	<b>26</b>	<b>350</b>	<b>350</b>	<b>700</b>

L-LectureHours/week; T-TutorialLectureHours/week; P-Practical hours/week, CIE-ContinuousInternal Evaluation; SEE-SemesterEndExamination(of3HoursdurationexceptCH7DCPEDwhichis4Hours)

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Subject Code		Subject Title	Program : BE					Semester: VII			
			Department of : Chemical Engineering					Contact Hrs/wk	Marks		
			Credits Hours/Week						CIE	SEE	Total
L	T	P	Total								
14CH7DC	CPU	Chemical Plant Utilities	3	0	0	3	3	50	50	100	
11CH7DC	CE	Biochemical Engineering	4	0	0	4	4	50	50	100	
11CH7DC	CE	Chemical Process Equipment Design and Drawing	3	0	1	4	5	50	50	100	
14CH7DC	CPMS	Chemical Process Modeling and Simulation	3	0	1	4	5	50	50	100	
14CH7DHS	S1	Project Management in Chemical Engineering	3	0	0	3	3	50	50	100	
11CH7DC	CPW	Pre-Project Work	0	0	5	5	5	50	50	100	
14CH7IE	CEP	Institutional Elective Courses	4	0	0	4	4	50	50	100	
		<b>Total</b>				<b>27</b>	<b>28</b>	<b>300</b>	<b>300</b>	<b>600</b>	

L-LectureHours/week; T-TutorialLectureHours/week; P-Practical hours/week, CIE-ContinuousInternal Evaluation; SEE-SemesterEndExamination(of3HoursdurationexceptCH7DCPEDwhichis4Hours)

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**Department of : Chemical Engineering      Program : BE      Semester: VIII**

Subject Code		Subject Title	Credits Hours/Week			Contact Hrs/wk	Marks		
			L	T	P		Total	CIE	SEE
14CH8DHS2	SS2	Process Engineering Economics	3	0	0	3	50	50	100
13CH8DCNET	ET	Non-conventional Energy Technology	3	0	0	3	50	50	100
11CH8DCFPW	PW	Final Project	0	0	12	12	50	50	100
11CH8DCIT S	TS	Industrial Trip & Related Seminar	0	0	2	2	50	50	100
14CH8IECK#	#	Institutional Elective Courses	4	0	0	4	50	50	100
<b>Total</b>						<b>24</b>	<b>300</b>	<b>200</b>	<b>500</b>

L-LectureHours/week;T-TutorialLectureHours/week; P-Practical hours/week,CIE-ContinuousInternal Evaluation;SEE-SemesterEndExamination(of3HoursdurationexceptCH7DCPEDwhichis4Hours)

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### THIRD SEMESTER B.E COURSE - (Common to all branches)

<b>Subject</b>	<b>ENGINEERING MATHEMATICS III</b>	<b>Course Code</b>	<b>11MA3ICMAT</b>
<b>Credits</b>	<b>04</b>	<b>L-T-P</b>	<b>3-1-0</b>
<b>Contact hours</b>	<b>52 hours (40L+12T)</b>		

#### UNIT I

##### FOURIER SERIES

[09 hours]

Infinite series, convergence and divergence of infinite series of positive terms, power series, periodic function, Dirichlet's conditions, statement of Fourier Theorem, Fourier series of periodic function of period 2 and arbitrary period, half range Fourier series, practical harmonic analysis.

[7 L + 2 T]

#### UNIT II

##### FOURIER TRANSFORMS

[09hours]

Infinite Fourier transform, Fourier Sine and Cosine transforms, properties, Inverse transforms, Convolution theorem (statement only), Parseval's identities for Fourier transform. Fourier transforms of the derivatives of a function.

[7L+2 T]

#### UNIT III

##### PARTIAL DIFFERENTIAL EQUATIONS

[12 hours]

Formation of Partial differential equations-elimination of arbitrary constants, elimination of arbitrary functions. Equations of first order- The linear equation  $P p + Q q = R$  (Lagrange's partial differential equation). Method of separation of variables.

[5L+2T]

##### APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

One-dimensional heat equation and wave equation (without proof), various possible solutions of these by the method of separation of variables, D'Alembert's solution of wave equation.

[4L+1T]

#### UNIT IV

##### NUMERICAL METHODS

[11 hours]

Finite Differences and interpolation: Forward differences, Backward differences. Interpolation:



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Newton-Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical differentiation: Numerical differentiation using Newton-Gregory forward and backward interpolation formula. [4L+2T]

Numerical integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule. Solution of algebraic and transcendental equations: Newton-Raphson method, Numerical solution of ordinary differential equations: Euler's modified method, Runge-Kutta method of fourth order. [4L+1T]

**UNIT V**

**Z -TRANSFORMS**

[11 hours]

Definition, Properties, Transforms of standard functions, Inverse transforms.

**APPLICATIONS OF Z-TRANSFORMS**

Solution of difference equations using Z- transforms.

[5L+1T]

**CALCULUS OF VARIATIONS**

Variation of function and functional, Euler's equation, variational problem.

**APPLICATIONS OF CALCULUS OF VARIATIONS**

Geodesics of a right circular cylinder, minimal surface of revolution, hanging chain, Brachistochrone problem.

[4L+1T]

**TEXT BOOKS:**

1. Advanced Engineering Mathematics, Erwin Kreyszig, 8th edition, 2007, Wiley-India
2. Higher Engineering Mathematics, B.S. Grewal, 40th edition, 2007, Khanna Publishers.
3. Introductory methods of Numerical Analysis, S. S. Sastry, 3rd edition, 1999, Prentice-Hall of India.

**REFERENCE BOOKS**

1. Advanced Modern Engineering Mathematics, Glyn James, 3rd edition, 2004, Pearson Education.



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(Autonomous College under VTU )

2. Higher Engineering Mathematics, B.V. Ramana, 2007, Tata Mc. Graw Hill.
3. Advanced Engineering Mathematics, P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.
4. Advanced Engineering Mathematics, 3rd edition by Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd..

**Question Paper Pattern:**

1. Each unit consists of one full question.
2. Each full question consists of three or four subdivisions.
3. Five full questions to be answered.
4. Internal Choice in Unit 4 and Unit 5

<b>Subject</b>	<b>Chemical Technology</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>0</b>	<b>9</b>	<b>C</b>	<b>H</b>	<b>4</b>	<b>D</b>	<b>C</b>	<b>C</b>	<b>T</b>	<b>N</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Familiarize with processing & flow diagram for manufacture of organic and inorganic chemicals.
- CO 2. Comprehend the various unit operations & processes involved.
- CO 3. Identify the engineering problems associated with the various processes.

**UNIT- I**

**INTRODUCTION TO CT AND FUELS** : Introduction- Components of flowsheet. Fuels and Industrial gases- Hydrogenation of coal, LNG, LPG, Ammonia synthesis gas, Petroleum technology Constituents, distillation of crude petroleum, Refining and processing (important chemical processes discussed briefly).Cryogenic industry- Nitrogen and Oxygen

**10 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- II**

**INORGANIC CHEMICALS** : Sulphur.-Mining process and Sulphuric acid - DCDA Process Alkali industry- Soda Ash, Caustic soda Nitrogen Industries- Ammonia and Nitric Acid. Phosphorous, phosphoric acid. (HCI leaching method) **12 Hrs**

**UNIT- III**

**NATURAL INDUSTRIALS:** Oil industry: vegetable oil extraction, Refining and hydrogenation. Surfactant industry: Manufacture of soap and detergents. Pulp and paper industry (sulfate process). Effluent treatment for sulfate process. Sugar industry. **12 Hrs**

**UNIT IV**

**COMMERCIAL INDUSTRIES:**

Fermentation industry- Manufacture of ethyl alcohol, penicillin Lime stone beneficiation and Cement LDPE, PVC, Rubber industry (Natural rubber and SBR) **09 Hrs**

**UNIT- V**

**MISCELLANEOUS INDUSTRIES:** Paints-Zinc oxide, Titanium dioxide Glass, Bromine Fertilizers- Urea,  $\text{NPK}_1$  biofertilizers, Coking of coal. **09 Hrs**

**TEXT BOOKS:**

1. George T.A. and Shreve's, Chemical process industries, 5<sup>th</sup> edition, McGraw Hill International Ltd., 1984.
2. GopalRao, M. and Marshall Sitting, Dryden's Outlines of Chemical Technology, 3<sup>rd</sup> Edition, Affiliated East West Press Pvt. Ltd., New Delhi, 1997

**REFERENCE BOOKS:**

1. Shukla SD and Pandey GN, Text book of chemical technology Volume 2, Vikas Publishing house Pvt Ltd., New Delhi, 1979.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
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**SEMESTER III Cluster CHEMICAL**

<b>Subject Title</b>	<b>FLUID MECHANICS</b>										<b>Credits</b>	<b>5</b>		
<b>Sub. Code</b>	<b>0</b>	<b>9</b>	<b>C</b>	<b>H</b>	<b>3</b>	<b>D</b>	<b>C</b>	<b>F</b>	<b>M</b>	<b>E</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO1: Apply the concept of pressure and classify fluids based on shear stress & rate relationships.
- CO2: Apply basic equations of fluid flow.
- CO3: Select relevant flow metering equipment and evaluate their performance.
- CO4: Develop correlations between process variables using dimensional analysis.

**UNIT - I**

**FLUID STATICS AND ITS APPLICATIONS:** Concept of unit operations, Concept of Momentum Transfer, Nature of fluids and pressure concept, Variation of pressure with height - hydrostatic equilibrium, Barometric equation, Measurement of fluid pressure - manometers (U-tube, Inverted U-Tube, Continuous gravity decanter, Centrifugal decanter, Differential manometers).

**FLUID FLOW PHENOMENA:** Types of fluids - shear stress and velocity gradient relation, Newtonian and non - Newtonian fluids, Viscosity of gases and liquids. Types of flow - laminar and turbulent flow, Reynolds stress, Eddy viscosity. Flow in boundary layers, Reynolds number, Boundary layer separation and wake formation.

**12 Hrs**

**UNIT - II**

**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.

**FLOW OF COMPRESSIBLE FLUIDS:** Basic equations of Compressible flow (Continuity, Bernoulli's or Energy equations, Momentum Equations and Equation



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

of state), stagnation properties, Compressible fluid through Venturi, Pitot-Static tube, Concept of Mach number, Velocity of sound or Pressure wave in a fluid, Ideal gas equations. **12 Hrs**

**UNIT - III**

**FLOW OF INCOMPRESSIBLE FLUIDS IN CONDUITS AND THIN LAYER:** Laminar flow through circular and non-circular conduits. Hagen-Poiseuille equation, Turbulent flow in pipes and closed channels,

Friction factor chart. Friction from change in velocity or direction. Form friction losses in Bernoulli equation. **12 Hrs**

**UNIT - IV**

**METERING OF FLUIDS:** Pipes, Fittings and valves, Measurement of liquid and gas flow rates by Orifice meter, Venturi meter, Rotameter and Pitot tube. Flow through open channels - weirs and notches.

**TRANSPORTATION OF FLUIDS:** Performance and characteristics of pumps - Positive Displacement and centrifugal pumps. Fans, Compressor and Blowers. **10 Hrs**

**UNIT - V**

**DIMENSIONAL ANALYSIS:** Dimensional homogeneity, Rayleigh's and Buckingham's II - methods. Significance of different dimensionless numbers. Elementary treatment of similitude between model and prototype **6 Hrs**

**LABORATORY COMPONENT**

1. Determination of Friction factor in circular pipes
2. Determination of Friction factor in non circular pipes.
3. Friction in helical spiral coils.
4. Flow rate measurement using Orifice meters (incompressible fluid)
5. Measurement of pressure drop in Packed bed
6. Measurement of pressure drop in Fluidized bed
7. Study and development of characteristics for centrifugal pump
8. Study of various pipe fittings and their equivalent lengths



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- 9 Fluid flow measurement using Venturi / Orifice meters (incompressible fluid)
10. Reynold's apparatus

**TEXT BOOK:**

1. McCabe. W.L.f et. al. "Unit Operations of Chemical Engineering", 5th edn., McGraw Hill New York 1993.

**REFERENCE BOOKS:**

1. Bansal R.K, A Textbook of Fluid Mechanics (VTU), Edition 2005, Laxmi Publications.
2. Coulson J. and Richardson. J.F., 'Chemical Engineering' Vol.II L., 5th edn., Asian Books (p) Ltd., New Delhi, 1998.

**SEMESTER III Cluster CHEMICAL**

Subject Title	TECHNICAL CHEMISTRY										Credits	4		
Sub. Code	0	9	C	Y	3	D	C	C	E	M	L-T-P	3	0	1

**Course Outcome**

- CO-1. Describe electronic displacement in organic molecules and reactive intermediates.
- CO-2. Describe the reaction mechanism at molecular level in various chemical processes in aliphatic and aromatic hydrocarbons.
- CO-3. Describe active methylene and organometallic compounds and their synthetic utility.
- CO-4. 1. Describe organochlorine and organophosphate insecticides, their preparation, applications and limitations.
- 4.2. Understand theories of color, techniques of application and synthesis of some commercial dyes.



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(Autonomous College under VTU )

- CO-5. Analysis of oils and fats and apply that knowledge to synthesize soaps and detergents.
- CO-6. Apply various techniques of organic synthesis and estimation of organic compounds in terms of the functional groups present in them.

**UNIT-I**

**REACTION MECHANISMS-I**

Bond cleavage- homolytic and heterolytic bond cleavage; concept of reactive intermediates carbocations, carbanions and free radicals. Formation, Structure and Stability of Reactive Intermediates with suitable examples. Electron displacements in molecules -Inductive effect, resonance effect, conjugation effect, hyperconjugation effect and electromeric effect with examples. Nucleophilic aliphatic substitution reactions-1Hr-SN1 reactions- Mechanism, kinetics stereochemistry of the products with suitable examples. SN2 Reaction- Mechanism, kinetics, stereochemistry of the product- Walden Inversion. Factors affecting SN1 and SN2 reactions. **8 Hrs**

**UNIT-II**

**REACTION MECHANISMS-II**

Elimination reactions-Dehydrohalogenation. E1 and E2 mechanisms. Discussion of mechanism, kinetics and geometry of the products, Factors favouring E reactions versus substitution reaction. Electrophillic addition reactions.

Electrophillic aromatic substitution reactions. (Benzene): Mechanism of Nitration ; Sulphonation, Halogenation and Friedel crafts alkylation and acylation reactions. Orientation influence of the substituent in the benzene ring on further substitution.

**8 Hrs**

**UNIT- III**

**ACTIVE METHYLENE COMPOUNDS AND ORGANOMETALLICS**

Definition of active methylene group and compounds with example

*Malonic ester*: Preparation and properties, synthetic application, Synthesis of mono carboxylic acids-butyrac acids, dicarboxylic acids, unsaturated acids, cinnamic acid, ketonic acid-acetoacetic acid, heterocyclic compounds



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(Autonomous College under VTU )

*Acetoacetic ester: Ketonic and acid hydrolysis*, Preparation and properties, basis for synthetic application, synthesis of mono and dialkyl derivatives, monocarboxylic acid - propionic acid, dicarboxylic acid succinic acid, unsaturated acids crotonic acid, heterocyclic compounds.

Organometallic Compounds: Definition and examples. Grignard reagent, preparation, synthetic application, synthesis of alkane, aldehydes and ketones. **8 Hrs**

**UNIT-IV**

INSECTICIDES: Introduction, classification into contact, stomach, systematic and fumigant. Insecticides explanation with example. Organochlorine insecticides - DDT and BHC, Cyclopentadienes- Aldrin and Dieldrin, Organophosphates-melathion.

DYES: Classification of dyes by structure and by method of application, colour and constitution chromophore, auxochrome theory, Modern theory of colour. Synthesis of azo dyes, Congo red. Synthesis of triaryl methane dyes- alizarin. Synthesis of vat dye, indigo. **8 Hrs**

**UNIT-V**

OILS AND FATS: Introduction as triglycerides, properties and uses, vegetable oils examples, analysis of oil- Acid value, saponification value and iodine value-their determination.

SOAPS AND DETERGENTS: Soaps definition, types, manufacture of soap, Detergents definition, various constituents of a detergent, Surfactants-anionic, cationic, zwitterionic and non ionic builders, Sud regulators, softeners and other additives, Cleansing action of detergent, Advantages of detergents over soaps. **7 Hrs**

**LABORATORY COMPONENT**

1. Nitration of nitrobenzene to m- dinitrobenzene
2. Acetylation of aniline by acetic anhydride
3. Preparation of benzoic acid from benzaldehyde
4. Bromination of acetanilide to p-bromoacetanilide
5. Diazotization of aniline and coupling with phenol



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**(Autonomous College under VTU )**

6. Estimation of alcohol by acetylation
7. Estimation of amino group by acetylation
8. Estimation of phenol by bromination
9. Estimation of esters by hydrolysis
10. Estimation of carboxylic acid by iodometric titration
11. Reduction of 0-nitro Aniline to 0- phenylene diamine

Lab components must comprise of experiments that reinforce the theoretical understanding of the corresponding theory subject. Outlines of the laboratory components should be mentioned by the respective staff members well before the commencement of the course.

**TEXT BOOKS:**

1. Arun Bahl and B.S. Bahl. "A Text Book of Organic Chemistry", 15<sup>th</sup> Edition, S. Chand and Company, New Delhi, 1998.
2. Jerry March and Michael B. Smith "Advanced Organic Chemistry" Wiley Publication, 2001

**REFERENCE BOOKS**

1. Morrison B.R. and Boyd L.L., "Organic Chemistry", 6<sup>th</sup> Edition ELBS, New Delhi, 1999.
2. Finar, "Organic Chemistry Vol I and II" ULBS Publishers, New Delhi.
3. Tiwari Melhrotra and Vishnoi, "Organic Chemistry" 7<sup>th</sup> Edition, S. Chand and Company, New Delhi, 1996.
4. Sykes Peter, "Guide Book to Organic Reaction Mechanism". ULBS Publishers, New Delhi.
5. Sharma B.K., "Industrial Chemistry". 11<sup>th</sup> Edition, S. Chand and Company, New Delhi, 2001



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**SEMESTER III Cluster CHEMICAL**

<b>Subject Title</b>	<b>MECHANICAL OPERATIONS</b>										<b>Credits</b>	<b>5</b>		
<b>Sub. Code</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>3</b>	<b>D</b>	<b>C</b>	<b>M</b>	<b>O</b>	<b>P</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Apply the basic working principles of different size reduction equipment for particle size analysis.  
CO 2. Analyse the flow of fluids through bed of solids, calculate the pressure drop & friction factor.  
CO 3. Familiarise with the different types of mixing, agitation and conveyance of solids and estimate the power required.  
CO 4. Acquaintance of the principles of separating high value solids.

**UNIT- I**

**PARTICLE TECHNOLOGY:** Particle size analysis, Specific surface area, Screens: Ideal and actual screen, Differential and cumulative size analysis, Effectiveness, standard screen series Motion of screens, Gyrotory screen shaker , Vibrating screen shaker, Trammels. Sub sieve analysis. Problems. **09 Hrs**

**UNIT- II**

**SIZE REDUCTION:** Forces used, Characteristics of products, Laws of size reduction Work Index, Verification of laws, Problems. Open circuit grinding, Closed circuit grinding, Wet and dry grinding, Equipments: Jaw crusher, Gyrotory crusher, Roll crusher, Attrition mill, Ball mill, Fluid energy mill, Hammer mill, Cutter . **09 Hrs**

**UNIT- III**

**FLOW OF FLUID PAST IMMERSED BODIES:** Drag, Drag coefficient, Particle Reynolds number. Ergun equation and its modifications Particle size determination by Kozeny Carmen equation. Fluidization Types and Applications. Conveying of solids: Belt conveyors Chain conveyors.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**FILTRATION:** Classification, Modification of Kozeny - Carman equation for filtration. Industrial filters: Filter press, Leaf filter, Rotary drum filter, Bag filter  
Suspended batch centrifuge, Filter aids. Principles of cake filtration.  
**14 Hrs**

**UNIT- IV**

**MOTION OF PARTICLES THROUGH FLUIDS:** Equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal settling velocity, motion of spherical particle in different regions, Criterion for settling, Hindered settling, Cyclones, hydro cyclones and air elutriator, Heavy media separation.  
Sedimentation, batch settling test, theories, application of batch settling test to design a continuous thickener and related problems. Storage of solids, open and closed storage.  
**13Hrs**

**UNIT- V**

**AGITATION AND MIXING:** Equipment, Types of impellers. Flow patterns in agitated vessels, Prevention of swirling, Power correlation and calculation. Mixers: Muller mixer, Ribbon blender, internal screw mixer, tumbling mixer.

**SEPARATIONS:** Electrostatic separation, Jigging, Froth floatation.

**SIZE ENLARGEMENT:** Pelletization, agglomeration **07Hrs**

**LABORATORY COMPONENT:**

1. Air elutriation
2. Air permeability
3. Batch sedimentation
4. Beaker decantation
5. Drop weight crusher
6. ICI sedimentation
7. Jaw crusher
8. Leaf filter
9. Plate and frame filter press
- 10 Screen effectiveness



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**TEXT BOOKS:**

1. McCabe, Warren, L., Smith, Julian, C. and Harriott, Peter, Unit operations of chemical engineering, 5<sup>th</sup> edition, McGraw-Hill, Singapore, 2000.

**REFERENCE BOOKS :**

1. Badger, Walter, L. and Banchero, Julius, T. Introduction to Chemical Engineering, 3<sup>rd</sup> edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1997.
2. Richardson, J.F., Harker, J. H., and Backhurst, J. R. Particle Technology and Separation Processes, 2<sup>nd</sup> volume, 5<sup>th</sup> edition, Replika Books Pvt. Ltd., New Delhi, 2003

**SEMESTER III Cluster CHEMICAL**

<b>Subject Title</b>	<b>Chemical Process Equipment Drawing</b>										<b>Credits</b>	<b>3</b>		
<b>Sub Code</b>	<b>0</b>	<b>9</b>	<b>C</b>	<b>H</b>	<b>3</b>	<b>D</b>	<b>C</b>	<b>E</b>	<b>Q</b>	<b>D</b>	<b>L-T-P</b>	<b>2</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Draw symbols of different equipment for process flow diagram.  
CO 2. Visualize and draw different views of vessels and their components.  
CO 3. Draw assembled sectional views of pumps and pipe fittings.

All units have drawing component

**UNIT - I**

**SECTIONAL VIEWS:** Representation of the sectional planes, Sectional, lines and hatching, selection of section planes and types of sectional views. **04 Hrs**

**PROPORTIONATE DRAWING OF PROCESS EQUIPMENT:**

Equipment and piping symbols, Vessel component; Vessel opening, Manholes, Vessel enclosures, Vessel support, Jackets, Shell and tube heat exchanger, Reaction vessel, Evaporator and fermenter. **07 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT - II**

**ASSEMBLY DRAWING** Joints: Cotter joint with sleeve, Socket and cotter Spigot joint, Flanged pipe joint, Union joint, gland and stuffing box joint and gland and stuffing box expansion joint. **08 Hrs**

**Valves:** Stop valve, Globe valve, Screw down Stop valve, Rams Bottom safety valver Non-return valve. **14 Hrs**

**Pumps:** Centrifugal pump, Gear pumps **06Hrs**

**Note:**

1. First angle projection to be followed.
2. Examination consists of one question on proportionate drawing (30marks) and one question on Assembly drawing (70 Marks)
3. Unit I: Proportional drawings and Unit II: Assembly drawings

**TEXT BOOKS:**

1. Gopal Krishna, K.R., Machine Drawing, 21<sup>th</sup> edition, Subhas publications, Bangalore, 2012.

**REFERENCE BOOKS:**

1. Bhatt. N.D., Machine Drawing, 14<sup>th</sup> edition, Charotar Publishing House Pvt. Ltd., Anand-Gujarat, 2011.
2. Joshi.M.V., Process Equipment Design, 3<sup>rd</sup> edition, Macmillan India Ltd., Delhi, 2006.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER IV Cluster CHEMICAL FOURTH SEMESTER B.E COURSE -**  
(Common to all branches except for BT)

<b>Course Name</b>	<b>Engineering Mathematics-IV</b>	<b>Course Code</b>	<b>11MA4ICMAT</b>
<b>Credits</b>	<b>04</b>	<b>L - T - P</b>	<b>3 -1- 0</b>
<b>Contact hours</b>	<b>52 hours (40L+12T)</b>		

**Course Outcome**

- CO 1 Estimate the relation between two variables and perform regression analysis.
- CO 2 Apply the basic principles of probability and probability distributions.
- CO 3 Compute joint probabilities of two random variables.
- CO 4 Calculate transition probabilities using Markov chain.
- CO 5 Construct analytic functions and evaluate real and complex integrals.
- CO 6 Discuss series solution of ordinary differential equations

**UNIT-I**

**STATISTICS**

**[10 hours]**

Curve fitting – Fitting a straight line, fitting of a parabola, fitting of curves of the form

$y = a + bx, y = a + bx^2, y = ae^{bx}$ ; Correlation and regression. **(4L+1T)**

**PROBABILITY 1**

Probability of an event, axiomatic definition, addition theorem, conditional probability, multiplication theorem, Bayes' theorem. **(4L+1T)**

**UNIT-II**

**PROBABILITY 2**

**[10 hours]**

Probability distributions: Random variables, Discrete probability distributions, continuous probability distributions, Some standard distributions: Binomial distribution, Poisson distribution, exponential distribution, normal distribution **(8L+2T)**

**UNIT-III**

**COMPLEX ANALYSIS 1**

**[10 hours]**

Function of a complex variable, Analytic functions, Cauchy-Riemann equations,



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

construction of analytic functions, Cauchy-Reimann equations in Polar form. Transformations-  $w = z^2$ ,  $w = e^z$  and  $w = \frac{a^2}{z}$ ,  $z \neq 0$ , Bilinear transformations.  
(8L+2T)

**UNIT-IV**

**COMPLEX ANALYSIS2**

[12 hours]

Complex integration-Cauchy's theorem, Cauchy's integral formula, Taylor's and Laurent's series, Singular points, poles, residues, the residue theorem.  
(5L+2T)

**SERIES SOLUTION OF DIFFERENTIAL EQUATIONS**

Series solution-Frobenius method, series solution of Bessel's differential equation leading to Bessel function of first kind, equations reducible to Bessel's differential equation, series solution of Legendre's differential equation leading to Legendre polynomials, Rodrigue's formula.  
(4L+1T)

**UNIT-V**

**PROBABILITY 3**

[10 hours]

**Joint Probability distributions:** Case of discrete random variables, mathematical expectation, correlation, covariance.

**Markov Chain:** Probability vectors, stochastic matrices, fixed points, regular stochastic matrices. Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states.  
(7L+3T)

**Text Books**

1. Advanced Engineering Mathematics, Erwin Kreyszig, 8<sup>th</sup> edition, 2007, Wiley-India
2. Higher Engineering Mathematics, B.S. Grewal, 40<sup>th</sup> edition, 2007, Khanna Publishers.

**Reference Books:**

1. Advanced Modern Engineering Mathematics, Glyn James, 3<sup>rd</sup> edition, 2004, Pearson Education.
2. Higher Engineering Mathematics, B.V. Ramana, 2007, Tata Mc. Graw Hill.
3. Advanced Engineering Mathematics, P. V. O' Neil, 5<sup>th</sup> Indian reprint, 2009, Cengage learning India Pvt. Ltd.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Question Paper Pattern**

1. Each unit consists of one full question.
2. Each full question consists of three or four subdivisions.
3. Five full questions to be answered.
4. Internal Choice in Unit 2 and Unit 4

**MATHEMATICS DEPARTMENT**  
**SYLLABUS (2011 - 2012)**  
**FOR STUDENTS ADMITTED TO II YEAR THROUGH LATERAL ENTRY**  
**(Common to all branches)**

<b>Course Name</b>	<b>Higher Mathematics -2</b>	<b>Course Code</b>	<b>11MA4IMDIP</b>
<b>Credits</b>	<b>04</b>	<b>L - T - P</b>	<b>3 -1- 0</b>
<b>Contact hours</b>	<b>52 hours (40L+12T)</b>		

**UNIT-I**

**INTEGRAL CALCULUS**

**[11 hours]**

Multiple Integrals – Double integrals, evaluation of double integrals by change of order of integration, evaluation of double integrals by changing to polar form, Triple integrals. Area and volume-illustrative examples **(4L+2T)**

Vector integration – Line integrals, surface integrals, Green's theorem, Stokes' theorem and Gauss divergence theorem (without proof, statement and problems). **(4L+1T)**

**UNIT-II**

**LAPLACE TRANSFORMS**

**[10 hours]**

Definitions, properties, transforms of elementary functions, transforms of derivatives and integrals, properties, Periodic function, Unit step function and impulse function. **(8L+2T)**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT-III**

**INVERSE LAPLACE TRANSFORMS**

**[11 hours]**

Inverse Laplace Transforms-properties, Convolution theorem.

**APPLICATIONS OF LAPLACE TRANSFORMS:** Solution of ordinary differential equations and simultaneous differential equations using Laplace transforms (initial-boundary value problems) **(8L+3T)**

**UNIT- IV**

**MATRICES**

**[10 hours]**

Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, Gauss-Seidel method. Characteristic values and Characteristic vectors of matrices. **(8L+2T)**

**UNIT- V**

**ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDER**

**[10hours]**

Linear differential equations of second and higher order with constant coefficients, method of variation of parameters, solutions of Cauchy's homogenous linear equation and Legendre's equation. **(8L+2T)**

**Text Books**

1. Calculus and Analytic Geometry by G.B.Thomas, R.L.Fenny and M.D.Weir, 2010, Pearson Education.
2. Higher Engineering Mathematics, B.S. Grewal, 40<sup>th</sup> edition, 2007, Khanna Publishers.
3. Higher Engineering Mathematics, B. V. Ramana, 7<sup>th</sup> reprint, 2009, Tata Mc. Graw Hill

**Reference Books:**

1. Advanced Engineering Mathematics, P. V. O'Neil, 5<sup>th</sup> Indian reprint, 2009, Cengage learning India Pvt. Ltd.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Note: Every student admitted to the BE program through lateral entry scheme with diploma qualification need to compulsorily register for this course during his 4<sup>th</sup> semester (EVEN). There is no Semester End Examination [SEE] for this Mandatory Course. The grade PP(Passed)/NP(Not Passed) will be awarded to the student based on the performance in the Continuous Internal Evaluation [CIE]. The candidates who do not secure the grade PP for the mandatory courses are not eligible for the award of the degree.**

<b>Subject Title</b>	<b>Material Science and Biomaterials</b>										<b>Credits</b>	<b>4</b>		
<b>Subject Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>4</b>	<b>D</b>	<b>C</b>	<b>M</b>	<b>S</b>	<b>B</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Understand structure of materials using crystal structure, elastic and plastic behaviour.
- CO 2. Analyze the physical and chemical properties of various materials through phase diagrams and phase transformations by heat treatment methods.
- CO 3. Select metals and biopolymers based on the properties for the specific applications.

**UNIT - I**

**Introduction:** Introduction to material science, classification of engineering materials. Bragg's law, principle of X-ray diffraction, determination of material structure and lattice parameters using X-ray diffractions and related numerical. Crystal imperfections: point, line and surface imperfections.

**8 hrs**

**UNIT - II**

**Phase diagram and phase transformations:** Phase rule, Single component system for Iron, Binary phase diagrams: Aluminium–Chromium, Lead–Tin, Silver–Platinum



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

systems, Lever rule. Typical phase diagrams for Copper-Zinc and Iron-Iron-Carbide systems.

**Nucleation and growth:** Types of nucleation and kinetics, growth and overall transformation kinetics. Isothermal transformation (TTT) Curves for eutectoid steel.

**13 hrs**

**UNIT - III**

**Deformation of materials and fracture:** Elastic deformation: elastic behaviour, atomic model derivation to find Young's modulus of material, relaxation processes for anelastic behaviour, spring-dashpot model for viscoelastic deformation.

**Plastic deformation:** Stress-strain curve, deformation by slip, deformation in polycrystalline materials, brittle and ductile fractures.

**Heat treatment:** Annealing, normalizing, hardening, martempering, austempering, hardenability, quenching, tempering, carburizing, cyaniding, nitriding, flame hardening .

**13 hrs**

**UNIT - IV**

**Typical engineering materials:** Metals and non-metals: General properties of ferrous metals, non-ferrous metals and alloys, Copper and its alloys, lead and its alloys, Nickel and its alloys, Alloys for high temperature service. Ceramic materials: Structure, polymorphism, mechanical, electrical and thermal properties of ceramics.

**10 hrs**

**UNIT - V**

**Biopolymers:** Microstructures, mechanical properties, and biocompatibility, applications in Medicines, drug delivery and drug carriers systems, tissue and organ replacements, Orthopaedic, dental and cardiovascular.

**8 hrs**

**Text books:**

1. Hajra Choudhury, S. K., Material Science and Processes, Indian Book Distributing Co., 2<sup>nd</sup> edition, Calcutta, India, 1982.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

2. V Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited, 5<sup>th</sup> edition, New Delhi, India, 2005

**Reference books:**

1. Callister's Materials Science and Engineering adapted by R Balasubramaniam, Wiley India (P) Limited, 8<sup>th</sup> edition, New Delhi, India, 2011.

**SEMESTER IV Cluster CHEMICAL**

<b>Sub. Code</b>	<b>PROCESSENGINEERING THERMODYNAMICS</b>										<b>Credits</b>	<b>4</b>		
<b>Sub. Title</b>	<b>0</b>	<b>9</b>	<b>C</b>	<b>H</b>	<b>4</b>	<b>D</b>	<b>C</b>	<b>P</b>	<b>T</b>	<b>D</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Solve problems related to heat and work interactions using laws of thermodynamics
- CO 2. Use ideal and real equations of state to establish fundamental properties of fluids.
- CO 3. Establish VLE data using various correlations and verify the feasibility of reaction through free energy calculations.

**UNIT - I**

FIRST LAW OF THERMODYNAMICS AND BASIC CONCEPTS: Heat reservoir and Heat engines, Reversible and Irreversible processes. Zeroth law of thermodynamics. First law of thermodynamics for different systems, Derivation for steady state flow process, principles of flow calorimeter.

SECOND LAW OF THERMODYNAMICS: General statements of the Second law, concept of

Entropy, The Carnot Principle, Calculation of entropy changes. Third law of thermodynamics.

**8 hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT - II**

**P-V-T BEHAVIOUR:** P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Virial equation. Compressibility charts, Thermodynamics diagrams. Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes.

**8hrs**

**UNIT- III**

**THERMODYNAMIC PROPERTIES OF PURE FLUIDS, AND SOLUTIONS:** Property relations for homogeneous systems, Clausius-Clapeyron equations, heat capacity, entropy, & energy relations, Gibbs-Helmholtz equation.

**PROPERTIES OF SOLUTIONS:** Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, Activity coefficient, Property changes of mixing, excess properties.

**13 hrs**

**UNIT - IV**

**PHASE EQUILIBRIA:** Criteria of phase equilibria, Criterion of stability, Duhem's theorem, Vapour-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 equation, Liquid-Liquid equilibrium diagrams.

VLE correlations equations: Vander wall, Margules & Willson equations.

**13hrs**

**UNIT - V**

**Chemical Reaction Equilibria:** 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 equilibria, phase rule for reacting system.

**10hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**TEXT BOOKS:**

1. "**Introduction to Chemical Engineering Thermodynamics**", Fifth edition, Smith J.M. and Van Ness H.C., McGraw Hill, New York, 1996.
2. Narayanan, K. V. Chemical Engineering Thermodynamics, Prentice Hall of India Private Limited, New Delhi, 2001.

**REFERENCE:**

1. Rao, Y.V.C Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.

**SEMESTER IV Cluster CHEMICAL**

Sub. Code	PROCESS HEAT TRANSFER										Credits	4		
Sub. Title	0	9	C	H	4	D	C	H	T	R	L-T-P	4	0	1

**Course Outcome**

- CO 1.** Perform heat flux calculations through constant and variable area elements and estimate optimum insulation thickness.
- CO 2.** Develop correlations using elementary dimensional analysis and comprehend the laws governing radiation mode.
- CO 3.** Functional design of heat transfer equipment.
- Co4.** Select appropriate extended surfaces to enhance the overall heat transfer coefficient.

**UNIT -I**

INTRODUCTION: Various modes of heat transfer Viz. Conduction, Convection and Radiation



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
**(Autonomous College under VTU )**

CONDUCTION. Fourier's law, Steady state unidirectional heat flow through single and multiple layer slabs, Cylinders and spheres for constant and variable thermal conductivity. **8 hrs**

**UNIT-II**

INSULATION: Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation.

EXTENDED SURFACES Fins -Types of fins, Derivation of fin efficiency for longitudinal fins, Fin effectiveness. Elementary treatment of unsteady state heat conduction. **13 hrs**

**UNIT -III**

CONVECTION· Individual and over all heat transfer coefficient, LMTD, LMTD correction factor. HEAT TRANSFER WITH PHASE CHANGE: Boiling phenomena, Nucleate and film boiling, Condensation  
-Film and Drop wise condensation, Nusselt's equations. **13 hrs**

**UNIT -IV**

Evaporation: Enthalpy Balance for single effect evaporator and calculations, BPE, Durrhing's Chart, Economy and capacity of Evaporators, Methods of Feeding multi effect evaporator, working of single effect natural Circulation evaporator. **9hrs**

**UNIT-V**

RADIATION: Properties and definitions, absorptivity, reflectivity/ emissive power and intensity of radiation, black body radiation, grey body radiation, Stefan-boltzmanlaw, wien's displacement law, kirchoff's law, view factors.

Radiation between surfaces-different shapes, radiation involving gases and vapours, radiation shields. **9 hrs**

**LABORATORY COMPONENT**

1. Shell and Tube Heat Exchanger
2. Double Pipe Heat Exchanger



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

3. Vertical condenser
4. Emissivity
5. Helical coil Heat Exchanger
6. Transient Heat Conduction(constanttemperature)
7. Bare Tube Heat Exchanger
8. Fin Tube Heat Exchanger
9. Packed Bed Heat Exchanger
10. Transient Heat Conduction(constantflux)

**TEXT BOOKS:**

1. Kern D.Q., "Process Heat Transfer"Mc Graw Hill NewYork,1965.  
McCabe,W.L.,et.al., "Unit Operations of Chemical Engineering",5th Edn,McGraw Hill, New York 2000.
2. Coulson J.M. and Richardson J.F., "Unit Operations of Chemical Engineering"Vol. 1,5th Edn, Chemical Engineering Pergamon and ELBS, McGraw Hill, New York 2000
3. Rao, Y.V.C., "Heat Transfer", 1st Edn., Universities Press (India) Ltd., New Delhi, 2000.
4. P.K.Nagr "Heat and Mass Transfer", Second Edition Tata McGrawhill publications.

**SEMESTER IV Cluster CHEMICAL**

<b>Sub. Code</b>	<b>CHEMICAL PROCESS PRINCIPLES &amp; CALCULATION</b>									<b>Credits</b>	<b>4</b>			
<b>Sub. Title</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>4</b>	<b>D</b>	<b>C</b>	<b>C</b>	<b>P</b>	<b>C</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1.** Verify the unit consistency of equations and unit conversion.
- CO 2.** Formulate material and energy balance for processes involving single & multiple components with & without reactions.
- CO 3.** Determine excess & limiting reactant, percentage conversion, extent and Selectivity of reaction.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT -I**

UNITS AND DIMENSIONS: Fundamental and derived units Conversion. Dimensional consistency of equations. Dimension less groups and constants. Conversion of equations  
**4hrs**

BASIC CHEMICAL CALCULATIONS: Concept of mole, mole fraction, compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, parts per million. Use of semi log and triangular graphs, Ideal gas law, Amagat's law and Dalton's law and related problems.  
**6 hrs**

**UNIT II**

PSYCHROMETRY: Vapour-Pressure concept, Clausius-Claypronequation. Cox chart and its use, Psychrometry, Absolute humidity, Molal humidity, Relative humidity, Dry bulb, Wet bulb thermometry, Humidity chart, Humidification and Dehumidification, Air-conditioning.  
**8hrs**

**UNIT -III**

MATERIALS BALANCE WITHOUT REACTION: General material balance equation for steady state. Steady state material balances in distillation, extraction, crystallization and drying.  
**7hrs**

Steady state material balance for mixing and evaporation. Elementary treatment of material balances involving recycling and bypass.  
**7hrs**

**UNIT -IV**

STEADY STATE MATERIAL BALANCE WITH REACTION: Principles of stoichiometry, Concept of limiting and excess reactants and inert, Fractional and percentage conversion, Fractional yield and percentage yield, Selectivity, Related problems.  
**7 hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
**(Autonomous College under VTU )**

Ultimate and proximate analyses of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, Air-fuel ratio calculations. **7 hrs**

**UNIT-V**

ENERGY BALANCE: General steady state energy balance equation, heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion, heat of mixing, determination of Heat of formation at standard and elevated temperatures, theoretical flame temperature and adiabatic flame temperature. **6hrs**

**TEXT BOOKS:**

1. K.V.Narayanan and B.Lakshmikutty' Stoichiometry and Process Calculations', Second Edition, 2009, PHI Learning private Ltd. New Delhi-110001
2. Bhatt B.L. and Vora S.M. 'Stoichiometry (SI Units)', Third Edition, 1996, Tata McGraw Hill Publishing Ltd., New Delhi -1996.

**REFERENCE BOOKS:**

1. Hougen O.A., Waston K.M. and Ragatz R.A., ' Chemical Process Principles Part -I' Material and Energy Balances, Second edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau D.M., "Basic Principles and Calculations in Chemical Engineering", 6th Edn. Prentice Hall of India, New Delhi 1997.

Charts: Psychrometric chart, steam tables



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>CHEMICAL REACTION ENGINEERING-1</b>										<b>Credits</b>	<b>5</b>		
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>C</b>	<b>C</b>	<b>R</b>	<b>1</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Develop rate equations for different reactions using suitable mechanism.
- CO 2. Fit the experimental data to obtain the rate equation and also to find the performance equation of ideal systems.
- CO 3. Determine optimal ideal reactor design for multiple reactions & predict reactor performance for non-isothermal conditions.

**UNIT – 1**

**INTRODUCTION:** Scope of Chemical Reaction Engineering, Classification of reactions, Rate equation and rate of reaction. Factors affecting rate of reaction. Chemical kinetics and Thermodynamics Equilibrium. Temperature- dependency of rate constant from Arrhenius, Collision and Transition state theories. Molecularity and order of reaction. **9Hrs**

**UNIT- II**

**NON-Elementary REACTIONS:** Difference between elementary and non- elementary reactions. Kinetic models and mechanisms for non-elementary reactions. Types of reactors. **9 Hrs**

**UNIT- III**

**HOMOGENEOUS REACTIONS:** Interpretation of batch reactor data. Constant & Variable Volume batch reactor. Analysis : Differential method, Integral method, half-life method. Method of excess and method of isolation (For Reversible and Irreversible reactions up to second order). Autocatalytic reactions.

**DESIGN OF IDEAL REACTORS:** Concept of ideality. Development of design equations for batch, tubular and stirred tank reactors for both constant and variable volume reactions. Evaluation of rate equations from data obtained in these reactors. **13 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**MULTIPIE REACTOR SYSTEMS:** Plug flow and/or Mixed flow reactors in Series, parallel and series parallel. Reactors of different types and sizes in series. Comparison Of Ideal Reactors, General graphical comparison.

**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). **13Hrs**

**UNIT- V**

**NON-ISOTHERMAL REACTORS:** Introduction, Material, Energy balances and conversions. Analysis of Non Isothermal Reactor: Design procedure (For single/simple reactions only). Optimum temperature Progression. **8 Hrs**

**LABORATORY COMPONENT**

1. Batch Reactor
2. Isothermal plug flow reactor
3. Mixed flow reactor
4. Semi batch reactor
5. Packed bed Reactor
6. RTD Studies in Tubular Reactor
7. Effect of temperature on Rate of reaction
8. Bio Chemical Reaction (Batch)
9. Enzyme catalyzed reactions in batch reactor
10. RTD Studies in mixed flow reactor
11. Adiabatic reactorc

**TEXT BOOKS**

1. Octave Levenspeil ,Chemical Reaction Engineering-,3<sup>rd</sup> edition.,. John Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering,3<sup>rd</sup> edition Prentice Hall2001.

**REFERENCE BOOKS:**

1. J.M. Smith, Chemical Engineering Kinetics -3<sup>rd</sup> Edition, McGraw Hill , 1984.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>MASS TRANSFER – 1</b>										<b>Credits</b>	<b>5</b>		
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>C</b>	<b>M</b>	<b>T</b>	<b>1</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Determination of diffusivities in fluids & solids and analogies amongst the transport processes.
- CO 2. Apply mass transfer fundamentals to calculate rates of mass transfer for various operations.
- CO 3. Get the knowledge of the principles of novel separation process.

**UNIT – 1**

**INTRODUCTION:** Diffusion in fluids, Diffusion in solids, measurement and calculations of diffusivities. Eddy diffusion: MT coefficients and their correlations. Theories of MT. Interphase MT, J factor, Analogies in Mass Transfer, Heat Transfer and Momentum transfer processes. **14 Hrs**

**UNIT- II**

**HUMIDIFICATION:** General theory, Psychrometric chart. Concepts in humidification/dehumidification. Equipment-cooling towers, spray chamber.

**DRYING:** Introduction, Equilibria, Drying rate curves, Mechanism of drying, types of dryers, Design of batch and continuous dryers. **14Hrs**

**UNIT- III**

**CRYSTALLIZATION:** Factors governing nucleation and crystal growth rates, Controlled growth of crystals, Incorporation of principles into design of equipment, Crystallizer equipments: Swenson-Walker and Continuous crystallizers. **6Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**ADSORPTION:** Theories of adsorption , Isothermal Industrial adsorbents. Material balance for co-current, cross current and counter current operations, concept of stages, cascades and equipments. **9 Hrs**

**UNIT- V**

**INTRODUCTION TO NOVEL SEPARATIONS:** Ion exchange, Membrane processes- Reverse osmosis, dialysis, ultra and micro filtrations, Super-critical fluid extraction. **6 Hrs**

**LABORATORY COMPONENT:**

1. Diffusion co-efficient of organic vapor into air.
2. Surface evaporation.
3. Drying characteristics.
4. Single stage adsorption.
5. Solid dissolution.
6. Multistage adsorption
7. Wetted wall column.

**TEXT BOOKS:**

1. Robert E. Treybal ,Mass transfer operations-3" edition. , McGraw Hill publications,
2. McCabe & Smith<sub>1</sub> Unit operations in chemical engineering- 6<sup>th</sup> edition, McGraw Hill publications.

**REFERENCE BOOKS:**

1. Geankoplis C. .J ,Transport processes and unit operations-, prentice Hall(I)
2. Coulson and Richardson<sub>1</sub> Chemical Engineering Vol I, II , IV & V- 4<sup>th</sup> edition<sub>1</sub> Pergamon press.
3. Badger, W.L. and Banchero J.T. "Introduction to Chemical Engineering" III Edn., McGraw Hill International Edition<sub>1</sub> Singapore 1999.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

Subject	Pollution Control & Management										Credits	3		
Sub.Code	1	4	C	H	5	D	C	P	C	L	L-T-P	3	0	0

**Course Outcome**

- CO 1. Identify the components of environmental eco systems and effect of pollutant on environment.
- CO 2. Characterize the various parameters for treatment of water, waste water as well as solid waste from their sources.
- CO 3. Recover and recycle the useful resources from the wastes by adopting advanced techniques.
- CO 4. Identify suitable equipments for abatement and control of air and noise pollution.

**UNIT- I**

**WATER POLLUTION:** Water as Resources, IS 10500 Drinking water quality, water consumption standards. Types of Water Pollutants and sources, State and central wastewater quality and its various discharge standards. Wastewater Sampling and Characteristics - Physical, Chemical and Biological characteristics of wastewater: Solving numerical on the sampling, characteristics and estimation of wastewater flow rates.

**08Hrs**

**UNIT- II**

**Wastewater Treatment:** Preliminary/Primary/physical unit operations, Chemical unit processes, Secondary/Biological treatment process aerobic/anaerobic attached and suspended growth process, Sludge treatment & Disposal. Solving numerical problems.

**08 Hrs**

**UNIT- III**

**Tertiary/Advanced wastewater Treatment:** Ultrafiltration, Filtration, Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electro dialysis cell. Wastewater treatment in Industries: Paper and Pulp, distillery, Leather, Food processing such dairy and fruit processing and Textile processing.

**07Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**AIR POLLUTION:** Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling. Analysis of air pollutants. Control methods and Equipments for particulates and gaseous pollutants. Applications to Industries: Thermal power plants, Metallurgical and Cement industries.

**NOISE POLLUTION:** Definition, Sources, Effects of Noise, Equipments Used for Noise Measurement, Approaches for Noise Control. **10Hrs**

**UNIT- V**

**SOLID WASTE MANAGEMENT:** Definitions, Characteristics and perspectives. Types of solid wastes, Sources of Solid waste, Properties of solid waste – Numerical problems, Solid waste Management – An Overview- Material flow in society, Reduction in raw material usage, Solid waste generation, and reuse with materials, energy recovery. **06Hrs**

**TEXT BOOKS:**

1. Environmental Engineering by Howard S. Peavey, Donald R. Rowe, George Tchobanoglous, McGraw-Hill International Editions,
2. Wastewater Engineering – Treatment, Disposal and Reuse, METCALF AND EDDY, INC. 3<sup>rd</sup> Edition Tata McGraw-Hill Publishing Company Limited.

**REFERENCE BOOKS:**

1. Air Pollution-M N. Rao- Tata McGraw-Hill Publishing Company Limited.
2. Environmental Pollution Control Engineering, C S Rao, New Age International Publisher, 2011.
3. Pollution Control in Process Industries, S P Mahajan, McGraw Hill Publishing.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>CHEMICAL EQUIPMENT DESIGN</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>C</b>	<b>C</b>	<b>E</b>	<b>D</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Realize the practical applications of basic engineering design principles.  
CO 2. Select the suitable materials based on the process, environmental, economic & safety.  
CO 3. Solve the numerical problems of various reaction/pressure vessel components.  
CO 4. Estimation of sizing of pipes, pumps & storage vessel with its accessories.

**UNIT - I**

**INTRODUCTION:** Basic considerations in design. General design procedure. Equipment classification. Various components of process equipment. Design parameters. Pressure vessel codes. **7 Hours**

**UNIT - II**

**DESIGN CONSIDERATIONS:** Material selection. Factors affecting design. Stresses due to static and dynamic loads (Internal & External). Temperature effects. Economic considerations.

**DESIGN OF PRESSURE VESSELS:** Design parameters, conditions & stresses. Design of shell and other vessel components. Vessel at low & high operating temperatures. Numerical design problems using given process parameters. **13 Hours**

**UNIT - III**

**VESSEL COMPONENT DESIGN:** Design of supports for vessels - Bracket, Lug, Leg, Saddle and Skirt supports. Design of flanges & nozzles - Classification of flanges. Flange thickness calculation, Gasket selection and design, Bolt selection and calculation. Nozzle design. Design of vessel closures - Flat plates, Formed heads, Elliptical & Hemispherical heads.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**REACTION VESSELS:** Design of reaction tanks with agitation and jacket. Types of agitators, baffles. Power requirement calculations. Design of tank dimensions and agitation system components. Numerical problems. **14 Hours**

**UNIT - IV**

**STORAGE VESSELS:** Process conditions and design parameters for storage of volatile, non volatile fluids & gases. Design of cylindrical tanks with fixed roofs. Design of components, supports and selection of vessels accessories & mountings. Numerical problems. **9 Hours**

**UNIT -V**

**PIPE LINE DESIGN:** Pipe line sizing, Condensate and steam pipe design. Optimum size of delivery line in pumping operations. Concepts of P & I Diagrams, P & I Diagram for simple processes. **8 Hours**

**TEXT BOOKS:**

1. M. V. Joshi, Process Equipment Design - Macmillan & Co. India, Delhi, 3<sup>rd</sup> Edn. reprint 1998.
2. Brownell & Young, Process Equipment Design - Vessel Design - John Wiley, 1951
3. S. D. Dawande, Process Design of Equipment - Vol 1 - Central Techno Publications. 3<sup>rd</sup>-J. Edn, 2003.

**REFERENCE BOOKS:**

1. Perry & Green, Chemical Engineers Handbook - 7<sup>th</sup> Edn, McGraw Hill, 1997.
2. Pressure Vessel Code - IS 2825 - IS Code, B.I.S., New Delhi, 1969.
3. Flow of Fluids through Valves, Fittings & Pipes Crane Amazon-2006.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>FOOD TECHNOLOGY</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>A</b>	<b>1</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Comprehend the physical properties of food and its transportation.
- CO 2. Identify sources of contaminants, adulterants with its prevention for safe and healthy food.
- CO 3. Discern different technologies involved in food processing & preservation.
- CO 4. Select biocompatible packaging and additives for food products.

**UNIT- I**

**Introduction to Food Engineering:** Introduction, general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing.

**9 Hrs**

**UNIT- II**

**Food Processing and Preservation:** Food deterioration – Causes, Aims and objectives of preservation and processing.

**Food Contamination and Adulteration:** Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. HACCP, FSSAI- The Food Safety and Standards Regulations, 2011.

**9 Hrs**

**UNIT - III**

**High-Temperature Preservation:** Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numericals; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave & Ohmic heating.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Low-Temperature Preservation:** principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidised bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation. **12Hrs**

**UNIT- IV**

**FOOD ADDITIVES:** Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. **10Hrs**

**UNIT- V**

**Extrusion Processes for Foods:** Introduction to Extrusion; Basic Principles of Extrusion; Extrusion Systems; Cold Extrusion; Extrusion Cooking; Single Screw Extruders; Twin-Screw Extruders.

**Packaging Concepts:** Introduction to packaging; food protection; product containment, commutation; convenience; mass transfer in packaging materials; permeability of packaging material to "fixed" gases; innovations in food packaging; passive packaging; active packaging; intelligent packaging; food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling. **12 Hrs**

**TEXT BOOKS:**

1. R.Paul Singh and Dennis R. Introduction to Food Engineering, Elsevier Science & Technology, 5th Edition, ISBN: 9780123985309, 2013

**REFERENCE BOOKS :**

1. Hosahalli S. Ramaswamy & Michele Marcotte, Food Processing: Principles and Applications, ISBN-13: 978-1587160080, CRC Press, 2005
2. Zeki Berk, Food Process Engineering and Technology, ISBN: 978-0-12-373660-4, Elsevier Science & Technology 2009.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

3. P.G. Smith, Introduction to Food Process Engineering Second Edition, Springer Press, ISBN 978-1-4419-7661-1, 2009
4. Subbulakshmi G. and Shobha A. Udupi, Food Processing and Preservation, New Age International Pvt. Ltd., ISBN: 8122412831, 2001.

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>PETROLEUM REFINING</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>A</b>	<b>2</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Infer & identify data of composition and thermal properties in refining and treatment of petroleum.
- CO 2. Familiarise with the different reforming techniques used for petroleum.
- CO 3. Get acquainted with cracking processes to obtain desired product.

**UNIT-I**

**COMPOSITION OF CRUDE:** Classification. Evaluation of petroleum. UOP-k factor. TBP analysis. EFV analysis. Average boiling point. ASTM curves. Thermal properties of petroleum fractions. **6Hrs**

**UNIT-II**

**PRODUCT PROPERTIES AND TEST METHODS:** Reid vapor pressure analysis. Gasoline and naphtha. Octane No. Oxidation stability. Additives for gasoline. Characterization: flash point, fire point, volatility, Diesel, octane testing, viscosity, Grades of diesels. Diesel additives. Lube oils: Types tests-carbon residue and viscosity index. **9 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT III:**

**CRUDE PRETREATMENT:** Pumping of crude oil. Dehydration of crude by chemical, gravity, centrifugal, electrical de-salter and comparison of each. Heating of crude, Crude distillation.

**TREATMENT TECHNIQUES:** Types of impurities present, Production and treatment of LPG by LNG technology. Sweetening operations for gases: Catalytic desulphurisation

**15 Hrs**

**UNIT IV:**

**CATALYTIC CRACKING:** Various catalytic cracking processes: Fluid catalytic cracking-flexi cracking. Theory of coking, various types of coking processes. Naptha cracking, theory and catalyst used for hydro cracking Naptha cracking, Hydro cracking. Theory of hydro cracking. Catalysts for hydro cracking.

**CATALYTIC REFORMING:** Theory. Factors influencing reforming, catalysts, feedstock requirements.

**15 Hrs**

**UNIT V:**

**THERMAL PROCESSES:** Reactions- theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials. **7 Hrs**

**TEXT BOOKS:**

1. Bhaskara Rao, Modern Petroleum Refining Processes Oxford & IBH Publication, 3rd Edition, Reprint, 1999.
2. Nelson, Petroleum Refinery Engineering - McGraw Hill, 4<sup>th</sup> Edition, 14<sup>th</sup> Reprint, 1982.

**REFERENCE BOOKS:**

1. Ram Prasad, Petroleum Refining Technology- Khanna Publishers, 1<sup>st</sup> Edition, 2000.
2. Nagnal J.M., Gate, Challenges in Crude Oil Evaluation- McGraw Hill.
3. Sland W.F. and Davidson R.L. Petroleum Processing - McGraw Hill, 1967.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>NANO TECHNOLOGY</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>B</b>	<b>1</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Apprehend different instrumental techniques to characterize nanoparticles for their morphology and structure
- CO 2. Select suitable fabrication techniques for synthesis of nanoparticles, ferromagnetic materials, quantum nanostructures, MEMS and NEMS.
- CO 3. Comprehend the application of nanomaterials in sensors, Lab on chip devices and drug delivery systems.

**UNIT-I**

**Introduction to Nanotechnology:** Beginning of Nanotechnology, Feynman's predictions, Moore's Law, atomic size and crystallography.

**Instruments for characterization:** Particle size determination, Surface structure, Microscopy: Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy; Spectroscopy: Infrared and Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic resonance. **8Hrs**

**UNIT-II**

**Properties of Individual Nanoparticles:** Metal nanoclusters, Semiconducting nanoparticles, rare gas and molecular clusters, methods of synthesis: RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods. **7 Hrs**

**Carbon nanostructures:** Carbon molecule, Clusters, Carbon nanotubes, Applications Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals. **7 Hrs**

**UNIT-III**

**Nanostructured Ferromagnetism:** Basics of ferromagnetism, Effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets. Optical and



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

vibrational spectroscopy: Infrared frequency range, luminescence, nanostructures in zeolite cage. **8 Hrs**

**UNIT IV:**

**Quantum wells, wires and dots:** Preparation of quantum nanostructures, Excitons, Single electron tunneling, applications: Infrared Detectors and Quantum dot lasers.

**6 Hrs**

**Biological materials:** Biological building blocks, biological nanostructures. Microelectromechanical systems (MEMSs): Fabrication, Devices and Applications, Nanoelectromechanical Systems (NEMSs) - Fabrication, Devices, Applications.

**8 Hrs**

**UNIT V:**

**Applications of Nanotechnology:** Nanosensors: Chemical, Mechanical, biological and gas sensors, Drug delivery Nanoparticles, Nano-porous solids for catalysis and Nanocosmetics.

**8 Hrs**

**TEXT BOOKS:**

1. Charles P. Poole, Jr., Frank J. Owens, Introduction to Nanotechnology, John Wiley and Sons, 2009.
2. ManasiKarkare, Nanotechnology – Fundamentals and Applications, International Publishing House Pvt. Ltd., 2010

**REFERENCE BOOKS:**

1. Handbook of Nanostructured Materials and Nanotechnology, Vol. 1-5, Academic Press, Boston, 2000.
2. CNR Rao, Nanoworld : An introduction to nanoscience and technology, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, 2010



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER V Cluster CHEMICAL**

<b>Subject</b>	<b>POLYMER PROCESSING</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>2</b>	<b>C</b>	<b>H</b>	<b>5</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>B</b>	<b>2</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Apprehend molten flow behaviour of polymer.
- CO 2. Familiarise with various processing techniques.
- CO 3. Select suitable techniques based on applications.

**UNIT-I**

**PRINCIPLES OF PROCESSING OF POLYMERS:** Melt processing of thermoplastics. Classification of processes, crystallization, orientation & shrinkage, Co polymers blendings, Compounding for engineering application, Stress – strain behavior, Practical assessment for long term behavior. **10hrs**

**UNIT-II**

**POLYMER EXTRUSION:** Single screw and double screw plasticating, Extruder zones, Extruder screws, Power calculation. Die and calibration equipment, Co extrusion, Extrusion coating, Extrusion film blowing, Reactive extrusion, Extrusion blow moulding for PET bottles, Wire drawing-PVC, Spinning. Application of various extruded products. Rheological aspects of extrusion and extrusion defects. Operational and maintenance of extrusion equipments. **10 Hrs**

**UNIT-III**

**INJECTION MOULDING :** Reciprocating screw injection moulding. Single impression mould. Multi impression moulds. Hot runner moulds, gates, mould Clamping force calculations. Control of pressure, temperature and time of injection .Thermoset and Fiber reinforced polymer injection moulding, Sandwich moulding and Injection blow moulding. Rheological aspects and defects of injection. Comparision of injection moulding and extrusion of injection. Operational and maintenance of injection moulding equipments. Reaction injection moulding. Applications. **13 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**COMPRESSION MOULDING , TRANSFER MOULDING, CALENDERING :** Compression moulding: Applications. Principles. Derivation of compression mould thickness or compaction force. Transfer moulding. Principles and operation of calendaring. Derivation of film thickness and pressure required for rollers. Gauge control during calendaring. Application of PVC calendered products. **13 Hrs**

**UNIT- V**

**THERMOFORMING AND ROTATIONAL MOULDING :** Thermoforming: Basic principles. Vacuum forming. Pressure forming. Description of operations. Product design. Application. Derivation of thermoformed product thickness. Rotational moulding: Principles. Operation & applications. **6Hrs**

**TEXT BOOKS :**

1. Morton Jones, 'Principles of Polymer Processing'.
- 2 . R.J. Crawford, 'Plastic Engineering'.

**REFERENCE BOOKS :**

1. 'Principles of Polymer Engineering', N.G. McCrum, C.P. Buckley,



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>CHEMICAL REACTION ENGINEERING - 2</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>C</b>	<b>C</b>	<b>R</b>	<b>2</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Distinguish the performance of non ideal with ideal systems.  
CO 2. Determine rate expression using reaction mechanisms of suitable model for catalytic & non catalytic reactions.  
CO 3 Develop design equation using models for heterogeneous reaction systems.

**UNIT- I**

**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. **8 Hrs**

**UNIT- II**

**NON CATALYTIC SYSTEMS:** Introduction to Fluid-Fluid reactions, Kinetics for straight mass transfer with out reaction, Kinetics for direct mass transfer with reaction for all types of reactions, significance of Hatta Number and related problems on fluid-fluid reactions.

**FLUID PARTICLE REACTIONS:** Introduction to Fluid-Particle reactions, selection of suitable model, Kinetics for different rate controlling steps for spherical particles of unchanging size and shrinking spherical particles, limitation of the shrinking core model, rate determining steps with combination of resistances and related problems. **14 Hrs**

**UNIT- III**

**CATALYSIS:** Introduction to catalysis. Properties of catalysts. Estimation methods for catalytic properties. Promoters, inhibitors etc, Mechanism of catalysis. Rate equations for different rate controlling steps **8 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**DEACTIVATION:** Deactivating catalyst, Mechanism, rate & performance equation.

**HETEROGENEOUS REACTIONS-** Introduction, Kinetic regimes for different heterogeneous systems.

**SOLID CATALYZED REACTIONS:** Rate equation for surface kinetics, Pore diffusion resistance combined with surface kinetics, Thiele modulus and enhancement factor, Porous catalyst particles and Heat effects during reaction. **14 Hrs**

**UNIT- V**

**PERFORMANCE EQUATION FOR DIFFERENT REACTION SYSTEMS :** Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates. Packed bed catalytic reactor & reactors with suspended solid catalyst. Fluidized reactors of various type.

**GAS-LIQUID REACTORS:** Trickle bed, slurry reactors. Three phase fluidized bed. **08 Hrs**

**TEXT BOOKS:**

1. Octave Levenspiel, Chemical Reaction Engineering - 3<sup>rd</sup> Edition, John Wiley & Sons - 2001.
2. J.M. Smith, Chemical Engineering Kinetics - 3<sup>rd</sup> Edition, McGraw Hill.

**REFERENCE BOOKS :**

1. James J. Carberry, Chemical & Catalytic Reaction Engineering - McGraw Hill - 1976.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering - 3<sup>rd</sup> Edition, Prentice Hall - 2001.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject Title</b>	<b>Instrumentation and Process Control</b>										<b>Credits</b>	<b>5</b>		
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>C</b>	<b>I</b>	<b>P</b>	<b>C</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Identify the appropriate instruments for a application and evaluate its performance.
- CO 2. Formulate transfer functions and predict responses to various forcing functions.
- CO 3. Evaluate the response behaviour of P, PI, PD and PID controllers.
- CO 4. Verify the stability of control systems.

**UNIT-I**

**INSTRUMENTATION:** Fundamentals, Static and dynamic characteristics. Indicators and recorders. Pressure measurement- Bourdon, diaphragm and bellow type gages. Vacuum measurements. Temperature measurement- Bimetal and resistance thermometers, thermocouples and pyrometers. **10 Hrs**

**UNIT-II**

**FIRST ORDER SYSTEMS:** Thermometer, level in a tank, mixing tank, STR, Linearisation of I order systems in series. Response for various input forcing functions. **10 Hrs**

**UNIT-III**

**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. **10 Hrs**

**UNIT-IV**

**CLOSED LOOP SYSTEM:** Basic components. Servo and regulator control. Controllers - P, I, D and On -Off modes. Controller combinations - Final control elements - Valves, actuators and valve positioners.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**CLOSED LOOP RESPONSE:** Block diagram, Closed loop transfer function, Transient response of servo and regulator control systems with various controller modes and their characteristics. **10 Hrs**

**UNIT- V**

**STABILITY:** Stability of linear control systems. Routh Test. Frequency Response - Bode diagrams.

**CONTROL SYSTEM DESIGN BY FREQUENCY RESPONSE:** Bode criterion. Gain and Phase margins. Ziegler - Nichols controller tuning, Cohen-Coon controller tuning.

**ROOT LOCUS:** Rules for plotting and problems.

**12 Hrs**

**LABORATORY COMPONENT:**

1. Thermometer
2. Single tank - Step Response
3. Non Interacting Tanks - Step Response
4. Interacting Tanks - Step Response
5. Pressure Vessel
7. Single tank - Impulse Response
8. Non Interacting Tanks - Impulse Response
9. Interacting Tanks - Impulse Response
10. Level control - P controller, PI controller, PD controller, PID controller
11. Valve characteristics.
12. Temperature Control - P Controller, PI Controller, PID Controller.

**TEXT BOOKS:**

1. Coughner & Koppel, Process System Analysis and Control - McGraw Hill, New Delhi, 2<sup>nd</sup> Edition, 1991.

**REFERENCE BOOKS :**

1. Coulson & Richardson, Chemical Engineering Vol. III, 3<sup>rd</sup> Edition - Pergamon Press, 1998.
2. George Stephanopoulos, Chemical Process Control - And Introduction to Theory & Practical/ Prentice Hall 111 New Delhi, 1998.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>MASS TRANSFER - 2</b>										<b>Credits</b>	<b>5</b>		
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>C</b>	<b>M</b>	<b>T</b>	<b>2</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Apply mass balance and composition balance in interfacial mass transfer.  
CO 2. Apply the concept of interfacial mass transfer in multiphase contact processes.  
CO 3. Design & working of various mass transfer equipments.

**UNIT - I**

**GAS LIQUID CONTACTING SYSTEMS:** Liquid and gas dispersion: Types, construction and working of tray and packed columns, types and properties of packing, tray efficiencies, HETP and HTU concepts, Concept of flooding, weeping, and entrainment. Comparison of tray and packed columns.

**ABSORPTION:** Equilibrium solubility of gases in liquids. One component transferred: Material balances. Counter current multistage operations: Isothermal only. Continuous contact equipment: Absorption of one component, Overall coefficients and transfer units, dilute solutions, Overall heights of transfer units. Design of packed towers from the data of NTU. Absorption with chemical reaction. **12 Hrs**

**UNIT- II**

**DISTILLATION :** Introduction, Vapour liquid equilibrium Estimation of VLE data, VLE for multi component systems. Flash vapourisation, Simple or differential distillation, Steam distillation, Continuous rectification, Design using McCabe Thiele method for binary mixtures. **14 Hrs**

**UNIT- III**

**DESIGN OF DISTILLATION COLUMN :** PonchonSavarit method. Efficiencies -overall, local, and Murphree plate efficiencies:Reboilers, Use of open steam, Vacuum, molecular, extractive and azeotropic distillations. **08 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- IV**

**LIQUID-LIQUID EXTRACTION** : Introduction, Ternary equilibrium. Solvent selection. Equipment and flow sheets: Single stage. Multi-stage cross-current. Insoluble systems, Continuous counter current multistage extraction, Equipments: Stage efficiency, stage type extractors( no design aspects): Mixer -settler cascades, Continuous contact equipments: packed towers, Rotating disc contactor, Pulsed column, Sheibel extractor, centrifugal extractor. **10 Hrs**

**UNIT- V**

**LEACHING OPERATION** : Introduction, Preparation of solid, Equipment for unsteady state operation and steady state operation Methods of calculation: Equilibrium diagrams, Single stage and multi-stage cross and counter current operations, Counter current, constant underflow case, leaching operation **8 Hrs**

**LABORATORY COMPONENT :**

1. Simple distillation
2. Steam distillation
1. Single stage leaching
2. Packed column distillation
3. Single stage extraction
4. Multistage extraction
5. Multistage Leaching

**TEXT BOOKS:**

1. Robert E Treybal, Mass Transfer Operations - 3rd Edition, McGraw Hill, 1981.
2. McCabe & Smith, Unit Operations in Chemical Engineering - 6<sup>th</sup> Edition, McGraw Hall, 2001.

**REFERENCE BOOKS :**

1. Coulson and Richardson, Chemical Engineering, Vol -II and V - 4th Edition, Pergamon Press, 1998.
2. Badger & Banchemo, Introduction to Chemical Engineering - TMH, 1998.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>Transport Phenomena</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>C</b>	<b>T</b>	<b>R</b>	<b>P</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Analyze the steady state operations for momentum, heat & mass transfers to interpret practical data.
- CO 2. Apply broad reasoning for shell momentum, energy & mass balances for laminar flows across various geometry and boundary conditions.
- CO 3. Understand the impact of equation of changes in various co-ordinate systems with its influence on analogies between momentum, heat and mass transport.

**UNIT- I**

**Introduction:** Momentum , Energy and Mass Transport operations, Newton's law of viscosity (NLV). Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction (FLHC). Fick's law of diffusion (FLD). Effect of temperature and pressure on transport properties of fluids. Numerical problems . **08 Hrs**

**UNIT- II**

**Velocity Distribution in laminar Flow:** Different Flow situations, Steady state Shell momentum balancesr Boundary conditions applicable to momentum transport problems, Flow over a flat plate, Flow through a circular tube, Flow through Annulus. Flow between parallel plates and a slit. Numerical problems . **14Hrs**

**UNIT- III**

**Steady State Shell Energy Balances:** General Boundary conditions applicable to energy transport problems of chemical engineering. Heat conduction through compound walls. Overall heat transfer coefficient based on inner and outer surface area.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Temperature Distribution in Solids and in Laminar Flow:** Heat conduction with internal generation by electrical, nuclear, viscous energy sources. Numerical problems. Heat conduction in a cooling fin. Forced and free convection heat transfer. **14 Hrs**

**UNIT- IV**

**Concentration Distributions in laminar Flow:** Steady state mass balances. General Boundary conditions applicable to mass transport problems of chemical engineering. Diffusion through stagnant gas and liquid films. Equimolar counter diffusion. Numerical problems.

**Concentration Distributions in Laminar Flow:** Diffusion with homogeneous and heterogeneous reaction. Diffusion into falling film - Forced convection mass transfer. Numerical problems. **09 Hrs**

**UNIT- V**

**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, Euler's equation. **07 Hrs**

**TEXT BOOKS;**

1. Bird, Stewart and Lightfoot, 'Transport Phenomena', Academic Press, 1994.

**REFERENCE BOOKS**

1. Welty, Wikes and Watson, 'Momentum Heat and Mass Transport, 4<sup>th</sup> Edn.r John Wiley



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject Title</b>	<b>APPLIED MATHEMATICS IN CHEMICAL ENGINEERING</b>										<b>Credits</b>	<b>3</b>		
<b>Sub.Code</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>C</b>	<b>1</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Develop ordinary and partial differential equations to solve Chemical engineering problems.
- CO 2. Use suitable numerical methods to solve the developed differential equations.
- CO 3. Apply finite difference method to solve unit operations and processes.

**UNIT-I**

**MATHEMATICAL FORMULATION OF THE PHYSICAL PROBLEMS:** Applications of law of conservation of mass in: mixing tank system, equilibrium batch still and single stage extraction. Applications of law of conservation of energy in: Gas compression, system, and Flow of heat from a fin and related numerical problems for all above physical systems.

**6 Hrs**

**UNIT-II**

**MATHEMATICAL FORMULATION OF COMPLEX PROBLEMS:** Plug flow model to obtain fluid flow velocity, mass transfer with reaction for gas-liquid contact, heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, rate expression for series and parallel homogenous reactions.

Solving related numerical problems using solutions for ordinary differential equations of first order and first degree, solutions for linear differential equations and solutions for simultaneous linear differential equations

**11 Hrs**

**UNIT -III**

**PARTIAL DIFFERENTIAL EQUATIONS:** Differentiation formulas for different partial derivatives with examples and Differentiation of implicit functions.

**FORMULATIONS OF PARTIAL DIFFERENTIAL EQUATIONS:** Formulations of partial differential equations for the continuity equation, Fick's second law of diffusion and heat conduction in rectangular coordinates



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**FINITE DIFFERENCES METHOD FOR STAGE PROCESSES:** Analysis of stage-wise Processes like multistage counter-current extraction, stirred-tank reactor system  
**10 Hrs**

**UNIT-IV**

**NUMERICAL METHODS:** Solutions of ordinary differential equations: Picard's methods, Taylor series method, Euler's method, modified Euler's method, Range-kutta method, Adam bashforth method. Solutions of partial differential equations. By direct partialIntegration, solution for heat conduction equation, solution for Laplace's equation.  
**6 Hrs**

**UNIT-V**

**Applications of Laplace Transforms:** Inverse Laplace transforms, initial and final value theorems. Applications to chemical engineering like level/ temperature in a single tank system, mixing tank, CSTR with first order reaction, interacting system and non-interacting system.  
**06 Hrs**

**TEXT BOOKS:**

1. Mickley H.S., Sherwood T.K. and Reed C.E., Applied Mathematics in Chemical Engineering - 3rd Edition, Tata McGraw Hill, 1999.
2. Jenson V.G. & Jeggrens G.V., Mathematical Methods in Chemical Engineering, 1977.

**REFERENCE BOOK:**

1. Rose L.M. Applications of Mathematical Modeling to Process Development and Design, - Applied Science Publishers Ltd., London, 1998.
2. William. L Luyben, Process Modeling Simulation and Control for Chemical Engineering 2nd Edition, McGraw Hill, 1990.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>OPERATION RESEARCH</b>										<b>Credits</b>	<b>3</b>		
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>C</b>	<b>2</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Get acquainted to find optimum solutions for numerical problems using LPP.
- CO 2. Solve assignment, transportation and sequencing problems for its optimal solutions.
- CO 3. Illustrate network constructions and find its feasible solutions for optimization of societal problems.

**UNIT I**

**INTRODUCTION:** Definition. Scope of Operations Research. Approach and limitations of O.R. Models. Characteristics and phases of O.R. Linear Programming Problems: Mathematical formulation of L.P. Problems. Graphical solution method.  
**06 Hrs**

**UNIT- II**

**ASSIGNMENT PROBLEMS:** Balanced and Unbalanced assignment problems. Maximization assignment problems. Travelling salesman problems.  
**09 Hrs**

**UNIT- III**

**TRANSPORTATION PROBLEM:** Basic feasible solutions by different methods. Finding optimal solution. MODI method. Degeneracy. Unbalanced transportation problems. Maximization Problems.  
**09 Hrs**

**UNIT- IV**

**SEQUENCING:** Johnson's algorithm.  $n$  jobs - 2 machines,  $n$  jobs -3, machines and  $n$  jobs- $n$  machines without passing sequence. 2 jobs- $n$ , machines. Graphical solutions.  
**06 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT- V**

**PERT-CPM TECHNIQUES:** Network construction. Determining time estimates and critical path. In network analysis. Variance and probability of completing the project. Calculation of different floats. Project duration. Crashing of simple networks.

**12 Hrs**

**TEXT BOOKS**

1. S. D. Sharma, Operation Research - 8th Edition, Kedarnath & Co, 2003.
2. Kanti swaroop, P. K. Gupta and Manmohan,, Operation Research - 9th Edition, S Chand & Co. 1999.

**REFERENCE BOOKS :**

1. L. S. Srinath, Introduction to Pert and CPM - 3rd Edition, East West, 1998
2. Hospach Buchan and Earnest Koenigberg, Scientific Inventory Management - 1989.

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>Computer Interface in Chemical Engineering</b>									<b>Credits</b>	<b>3</b>			
<b>Sub.Code</b>	<b>1</b>	<b>0</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>D</b>	<b>1</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**CourseOutcome**

- CO 1. Comprehend the basics of C-programming and MAT lab for solving chemical engineering problems
- CO 2. Apply suitable numerical methods to solve iterative chemical engineering problems
- CO 3. Apply C-programming concepts to design and interpret the behavior of mass, heat transfer and reaction engineering operations



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT I**

**Review on C – programming:** Constant and name variable declaration, basic input and output statement, operators. Conditional statements: if-else, nested if-else and switch/case statements. Looping Statements: for loop, while loop and do-while loop statements. Arrays: Declaration of arrays, storing values in arrays, operations that can be performed on arrays, dimensional arrays for inter-function. Creating functions in C.

**6 Hrs**

**UNIT - II**

**Numerical computation using C:** Non-linear algebraic equation using Newton Raphson. Ordinary Differential Equation using R-K Method, Numerical Integration using Simpson's 1/3 Rule. Curve fitting using linear regression and non-linear regression methods. Algorithm and C–programs for all numerical methods.

**6 Hrs**

**UNIT - III**

**Prediction of physical properties using C:** Vapor- Liquid equilibria for binary mixtures, Calculation of Bubble Pressure and Bubble Point. Calculation of Dew Pressure and Dew point for Ideal Binary and multi-component system, Flash Vaporization for multi-component system.

**9 Hrs**

**UNIT - IV**

Applications of C in heat and Mass transfer operations: Design of Distillation column, Design of single stage Evaporation, design of double pipe heat exchanger (Area, Number of tubes, Pressure drop) and design of shell and tube heat exchanger(Area, Number of tubes, Pressure drop).

Application of C in Reactor design: Design of ideal isothermal Batch, plug flow and CSTR reactors. C-programing for CSTRs in series for both constant and variable volume.

**12 Hrs**

**UNIT - V**

Introduction to MAT Lab: MAT Lab environment, developing M-files, Basic output and input statements, conditional statements, looping statements and plotting.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

Applications using MAT Lab in chemical engineering: Specific volume of real gases, bubble point and dew point calculation, simple differential distillation, reactor tanks, crystallization. **6 Hrs**

**TEXT BOOKS:**

- 1 Raul Raymond Kapuno., "Programming for Chemical Engineers Using C, C++, and MATLAB", Infinity Science Press, 2010.
2. PradeepAhuja, "Introduction to Numerical Methods in Chemical Engineering", PHI Learning Pvt. Ltd., 2010.

**REFERENCE BOOKS:**

1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., McGraw Hill, 1990.

**SEMESTER VI Cluster CHEMICAL**

<b>Subject</b>	<b>Interfacial phenomena and related separation techniques</b>										<b>Credits</b>	<b>3</b>		
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>6</b>	<b>D</b>	<b>E</b>	<b>L</b>	<b>D</b>	<b>2</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Comprehend the concept of surface and interfacial tension and select surface tensionmeasuring instruments for measuring tensions.
- CO 2. Analyse the factors influencing stability of emulsions.
- CO 3. Comprehend about detergency, surfactants and their applications.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Unit-I**

**Introduction:** Concept of Interface. Surface Tension, Equivalence in the concepts of surface energy and surface tension. Application on interfacial science in industries.

**Excess Pressure:** Generalized equation for excess pressure across a curved surface- the equation of Young and Laplace and its application. Kelvin's equation and its application, Capillary condensation{ Super Saturation, Nucleation.  
**8Hrs**

**Unit-II**

**Measurement of Interfacial tension:** Capillary rise method. Drop weight method, Wilhelmy plate method, Du Nuoy method. Methods based on shape of static drops or bubbles.  
**6 Hrs**

**Unit - III**

**Wetting fundamentals and contact angles:** Work of adhesion, cohesion. Criteria for spreading of liquids. Kinetics of spreading. Lens formation- three phase systems. Young's equation. Contact angle hysteresis.

**EMULSIONS AND MICROEMULSIONS:** The conditions required to form emulsions and microemulsions, charged colloids, emulsions in food science, photographic emulsions.  
**10Hrs**

**Unit - IV**

**Electrical aspects of surfaces:** The electrical double layer. Stern treatment of electrical double layer. Free energy of a diffused double layer. Repulsion between two plane double layers. Colloidal dispersions. Combined attractive and electrical interaction-DLVO theory.  
**7 Hrs**

**UNIT- V**

**Surfactants:** Introduction to surfactants, common properties of surfactant solution, Thermodynamics of surfactant self assembly, self assembled surfactant structures, surfactants and detergency



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Surfactant Based Separations:** Fundamentals. Classification of surface active molecules like proteins and enzymes. Surfactants at inter phases and in bulk. Liquid membrane permeation. Foam separations. Micellar separations. Soil remediation.

**8 Hrs**

**TEXT BOOKS:**

1. Pallab Ghosh, Colloids and Interface Science, Prantice Hall Publications

**REFERENCE:**

1. A. W. Adamson, Physica I chemistry of surfaces, John Wiley, Stl1 edition, 1997.
2. Duncan J. Shaw, Butterworth Heinemann, Introduction to colloid and surface chemistry, 4th edition.

**SEMESTER VII Cluster CHEMICAL**

Subject	Chemical Plant Utilities										Credits	3		
Sub.Code	1	4	C	H	7	D	C	C	P	U	L-T-P	3	0	0

**Course Outcome**

- CO 1. Identify different utilities required for chemical plants.  
CO 2. Select suitable type of equipment for targeted requirement  
CO 3. Calculate power requirement and efficiencies of the equipment used.

**UNIT- I**

**Compressed Air:** Types, construction and working of reciprocating (Single and double), centrifugal and gear compressors, fans and blowers. Power requirement and performance Calculations

**Vacuum Systems:** Basic Concepts of vacuum and pressure and its measurement, Components of a vacuum system like vacuum chamber, pumps, gauges, valves, seals, and many other subsidiary components. Vacuum Generation, application and Piping

Nitrogen: Use and Storage of liquid Nitrogen

**9Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Steam and Power:** Fire tube boilers and water tube boilers, mountings and accessories Boiler performance and its Calculation, Cogeneration power plants, Fuels: Types, Calorific value. Proximate and ultimate analysis and its calculations **07 Hrs**

**UNIT- III**

**Refrigeration and Air Conditioning:** Refrigeration cycles, Refrigerants and their characteristics, chilled water plant, Coefficient of performance and Power requirement and related calculations.

**Air-conditioning systems and Cold Storage Insulation:** Types of insulation, Different types of insulating materials and their Characteristics. Selection criteria for insulating materials. **09Hrs**

**UNIT-IV**

**Cool Water:** Principle and construction of cooling towers, humidification and dehumidification chambers and related calculation.

**Utility Piping:** Chilled Water Insulation Piping, Compressed Air Piping, Water Utility Piping, Cooling Coil Heat Transfer, Anti Fire Pipes and steam piping, colour codes for piping. **07Hrs**

**UNIT- V**

Water and its treatment: Sources of water, hard and soft water Requisites of industrial water and its uses, Methods of water treatment: Chemical softening, Demineralization Resins used for water softening, Reverse osmosis and membrane separation, Effects of impure boiler feed water & its treatments. **07Hrs**

**TEXT BOOKS:**

1. Facility Piping Systems Handbook: For Industrial, Commercial, and Healthcare Facilities", Michael Frankel, 3<sup>rd</sup> edition, McGraw-Hill Professional publication
2. Thermal Engineering, B.K. Sarkar, Tata McGraw Hill
3. Handbook for process Plant Project Engineers, Peter Water mayer, Professional Engineering Publishing, 2002.
4. Refrigeration and Air conditioning, C.P. Arora, Third Edition, McGraw Hill Companies.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**REFERENCE BOOKS**

1. Power Plant Engineering, P.K. Nag, Tata McGraw Hill-1998
2. Perry's Chemical Engineering Hand Book, 8th Edition, McGraw Hill

<b>Subject</b>	<b>Biochemical Engineering</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>C</b>	<b>B</b>	<b>C</b>	<b>E</b>	<b>L-T-P</b>	<b>4</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Apply basic & advanced biology in bioprocess engineering.  
CO 2. Identify enzymes and explain the kinetics of enzyme catalysed processes.  
CO 3. Perform the basic analytical techniques and infer features of bioreactors.  
Decide various separation procedures in the downstream processing.

**Unit-I**

**Introduction:** Bioprocess engineering and technology. Role of a Chemical engineer in bioprocess industry. An introduction to basic biological sciences. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Taxonomy, Environmental and Industrial microbiology. Biochemistry: Chemicals of Life: Lipids, Sugars, Polysaccharides, Amino acids and proteins, Vitamins, Biopolymers, Nucleic Acids: RNA, DNA and their derivatives (Structure, Biological function and Importance for life only to be studied). **13Hrs**

**Unit-II**

**Enzymes and Proteins:** structure of proteins and enzymes. Functions. Methods of Production and purification of Enzymes. Nomenclature and Classification of enzymes. Kinetics of Enzyme action: Michaelis-Menten rate equation. Derivation.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**Kinetics of Enzyme action:** Reversible Enzyme. Two-substrate. Multi-complexes enzyme kinetics (Derivation of rate equations). Experimental determination of rate parameters: Batch and continuous flow experiments. Lineweaver-Burk, Eadie-Hofstee and Hanes-Woolf Plots. Batch Kinetics (Integral and Differential methods). **13Hrs**

**Unit III**

Enzyme Inhibition: Effect of Inhibitors (Competitive, noncompetitive, uncompetitive, substrate and product inhibitions), Temperature and pH on the rates enzyme catalyzed reactions. Determination of kinetic parameters for various types of inhibitions. Dixon method. Enzyme immobilization. Uses. Methods of enzyme immobilization. **7Hrs**

**Unit IV**

**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 in ideal chemostat. introduction to Fed-Batch reactors. **06 Hrs**

**Unit V**

**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. Alternate bioreactor configurations. Introduction to sterilization of bioprocess equipment.

**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, Ultra filtration, Micro filtration, Dialysis. **13 Hrs**

**TEXT BOOKS:**

1. Bailey and Ollis, 'Biochemical Engineering Fundamentals', 2nd Edition, McGraw Hill, 1976.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

2. Shuler M. L. and Kargi F., 'Bioprocess Engineering', 2<sup>nd</sup> Edition, Prentice Hall, 2002.

**REFERENCE BOOKS:**

1. James Lee, 'Biochemical Engineering', John Wiley.
2. Atkinson A. 'Bio-chemical Reactors',
3. Pelczer, 'Microbiology Concept and Application', 5th Edition, McGraw Hill, 2001 Reprint.

**SEMESTER VII Cluster CHEMICAL**

<b>Subject</b>	<b>Chemical Process Equipment Design and Drawing</b>									<b>Credits</b>	<b>4</b>			
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>C</b>	<b>P</b>	<b>E</b>	<b>D</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Congregate data from the literature, Handbook, Code book etc.
- CO 2. Analyze, interpret, and design the heat and mass transfer equipments.
- CO 3. Decide on the incorporation of inherent safety standards.  
Draft the equipments as per the design.

Detailed chemical engineering process design of the following equipment. Necessary aspects studied in "Chemical Equipment Design" is to be applied for mechanical design Use of standard code books to be taught. The detailed dimensional drawings shall include sectional front view, Full Top/side view depending on equipment and major component drawing with dimensioning and part Template.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

1. Double pipe Heat exchanger
2. Shell and Tube Heat exchanger
3. Condensers - Horizontal and vertical
4. Evaporator - Single effect
5. Bubble Cap Distillation Column
6. Packed Bed Absorption Column
7. Rotary Dryer.

**NOTE;** The question paper to contain Two full design problems (100 Marks each) for the equipment from the above list and student to answer any One. Perry's Chemical Engineers Handbook shall be allowed in the examination as reference.

IS Code 4503 for Heat Exchangers (if required) shall be permitted.

**TEXT BOOKS:**

1. S B Thakore and B I Bhatt, 'Introduction to Process Engineering and Design', 3rd Edition, Tata McGraw-Hill, 2011
2. Donald Q. Kern, 'Process Heat Transfer', McGraw Hill, 1997.
3. Robert E<sub>1</sub> Treybal, 'Mass Transfer Operations'<sub>1</sub>, McGraw Hill, 1981.

**REFERENCE BOOKS**

1. R.H. Perry & D.W. Green, 'Chemical Engineers Handbook', 7<sup>th</sup> Edition, McGraw Hill, 1998.
2. J.M. Coulson & J.F. Richardson <sub>1</sub>, 'Chemical Engineering'<sub>1</sub> Vol 6, Pergamon Press, 1993
3. Shell & Tube Heat Exchanger - IS Code, IS 4503, BIS, New Delhi, 1969
4. S.D. Dawande, 'Process Design of Equipment', Vol II, 3rd Edition, Central Techno Publications, 2003



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VII Cluster CHEMICAL**

<b>Subject</b>	<b>Process Modeling And Simulation</b>										<b>Credits</b>	<b>4</b>		
<b>Sub.Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>C</b>	<b>P</b>	<b>M</b>	<b>S</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>1</b>

**Course Outcome**

- CO 1. Understand the physical laws and mathematical models for reactor modules  
CO 2. Select suitable shell balance approach to build models for heat transfer and separation processes.  
Co3. Apply the simulation principles to solve build in models for reactors, heat and separation processes.

**UNIT-I**

**Fundamentals of Modeling:** Introduction to process modeling, Needs of model and their classification, Model building, Precautions in model building, Principles of model formulation, Fundamental laws, Review of shell balance approach, Models based on thermodynamic principles, Concept of degree of freedom analysis, Concept of equilibrium and kinetics.

**06 Hrs**

**UNIT-II**

**Models of reactors:** Two heated tanks, Gas phase pressurized CSTR, Non isothermal CSTR: Perfectly mixed cooling jacket, Plug flow cooling jacket, Lumped Jacket Model, Lumped metal model, Reactor model with mass transfer, Bioreactor models. Fluidized bed reactor model.

**09 Hrs**

**UNIT- III**

**Models of Heat Transfer equipment:** One and Two dimensional heat conduction, Numerical solution of one-dimensional transient heat conduction in a rectangular slab, cylinder, and sphere using the finite difference method, Numerical solution of Two-dimensional transient heat conduction using Gauss-Seidel, Red-Black Gauss-seidel, and Alternating Direction Implicit (ADI) methods.

**09 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT-IV**

**Models of Separation Processes:** Single –Component Vaporizer: Steady State model, liquid phase dynamic model, Liquid and vapor dynamic model, Thermal equilibrium model. Development of detailed mathematical models of multicomponent flash drum. Model of ideal binary distillation column, multicomponent non-ideal distillation column and Batch distillation with holdup.

**09 Hrs**

**UNIT-V**

**Simulation:** Introduction to process simulation, Tools of simulation: Features, advantages and limitations. Approaches of simulation: Modular approach and Equation solving approach. Flow sheeting, Introduction to dynamic simulation and process optimization.

**06 Hrs**

**LABORATORY COMPONENT**

Simulation Using UniSim® Simulation Software

1. Simulation of Mixer, Heater and Pump.
2. Simulation of Heat Exchanger
3. Simulation of Flash Drum for Binary Mixture
4. Simulation of Distillation Column
5. Simulation of Refrigeration Gas Plant
6. Simulation of Conversion Reactor
7. Simulation of Equilibrium Reactor
8. Simulation of Two Stage Compression System
9. Simulation of Absorption Column
10. Dynamic Simulation using Reactor

**TEXT BOOKS**

1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd Edition., McGraw Hill, 1990.
2. PradeepAhuja, "Introduction to Numerical Methods in Chemical Engineering", PHI Learning Pvt. Ltd., 2010.
3. B. V. Babu, "Process Plant Simulation", Oxford University Press, 2004

**REFERENCE BOOK**

1. EnesKadic, Theodore J. Heindel, "An Introduction to Bioreactor Hydrodynamics and Gas-Liquid Mass Transfer", Willey, April 2014.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VII Cluster CHEMICAL**

<b>Subject</b>	<b>Project Management in Chemical Engineering</b>										<b>Credits</b>	<b>6</b>		
<b>Sub.Code</b>	<b>1</b>	<b>4</b>	<b>C</b>	<b>H</b>	<b>7</b>	<b>D</b>	<b>H</b>	<b>S</b>	<b>S</b>	<b>1</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- Co1. Students understand the concept of a project with relevance to industry and chemical industry in particular.
- Co2. Students understand the various stages and procedures involved in conducting industrial projects.
- Co3. Comprehend ideas like project selection, planning, implementation, success and review.

**UNIT- I**

**Project planning:** Overview of project planning, Resource Allocation strategies, generation and screening of project ideas and plans **06 Hrs**

**UNIT- II**

**Project analysis:** Analysis, Market and demand analysis, Technical analysis, financial requirements and estimation. **06 Hrs**

**UNIT-III**

**Project selection:** Time value of money, Investment criteria, Cash flows, Cost of capital, Risk factors and analysis and Analysis of rate of return. **08 Hrs**

**UNIT-IV**

**Financing of projects:** Raising capital methods and means, Venture capital, Credit risk rating, Case studies and corporate examples in brief. **08 Hrs**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT-V**

**Implementation and review of project:** Time &. Cost control tools, Project quality control- Importance of environmental & Safety aspects, Project termination: Commissioning, Start UP: stabilization, Close out.

**Project scheduling & execution:** CPM and PERT (Critical Path, Float, Total Float, AON, AOA Diagram), GANTT charts, LOB, Resource Allocation, ABC analysis, VED analysis, EOQ, CAT & RAT (Numerical problems included). **10 Hrs**

**TEXT BOOKS**

1. Prassanna Chandra, "PROJECTS", Tata McGraw Hill, 7<sup>th</sup>edn.
2. SadhanChoudhury, "Project Management: , Tata McGraw-Hill Education, 1988

**REFERENCE BOOKS**

1. J.K.Sharma "OPERATION RESEARCH" MacMillan
2. Entrepreneurship Development, Colombo Plan Staff College for Technical Education, Tata McGraw Hill.

Subject Title	PRE PROJECT WORK										Credits	3		
Sub. Code	1	1	C	H	7	D	C	P	P	W	L-T-P	3	0	0

**Course Outcomes:**

- CO1: Identify a challenge related to process industries and/or the society with or without multidisciplinary facets.
- CO2: Select a suitable method amongst the various options available through literature survey.
- CO3: Formulate and report methodical approach to carry out the experiment to find a feasible solution.

A project is assigned at the beginning of the seventh semester. The project group should complete the preliminary literature survey & plan of project and submit the synopsis at the end of seventh semester with a literature survey and plan for the experimental work to be performed with all parameters.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VIII Cluster CHEMICAL**

Subject	Process Engineering Economics										Credits	3		
Sub.Code	1	4	C	H	8	D	H	S	S	2	L-T-P	3	0	0

**Course Outcomes**

- CO1: Comprehend the basic concepts of plant location, design and report writing.  
CO2: Analyze and solve depreciation and interest related problems in chemical engineering.  
CO3: Solve problems on profitability and replacement analysis, financial statements and break-even analysis.

**UNIT- I**

**Introduction to Process Engineering Economics:** Factors affecting plant location, Factors affecting plant layout, feasibility survey, design report, types of reports, organization of a design report **06 Hrs**

**UNIT- II**

**Cost analysis:** Fixed and working capital investment, cost indexes, estimating equipment cost by scaling, component of total product cost, problems. **07Hrs**

**UNIT- III**

**Interests:** simple, compound, nominal and effective interest rates, continuous interest, present worth and discount, meaning of annuities, Taxes: property, excise and income taxes Depreciation: types of depreciation, methods for determining depreciation: straight-line method, Unit of production method, Text book declining-balance method, double-declining balance method, sum-of-the-years-digits method and sinking-fund method, problems on interest and depreciation **11 Hrs**

**UNIT- IV**

**Profitability, Alternatives and Replacement:** Mathematical methods for profitability evaluation: rate of return on investment, discounted cash flow based on full-life



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
**(Autonomous College under VTU )**

performance, net present worth, capitalized costs, pay-out period, numerical problems,  
Alternative investment and replacements **10 Hrs**

**UNIT- V**

Financial Statements: Balance Sheet, Income Statement, Profit and Loss statement,  
Concept of breakeven point and chart, Break-even analysis, problems **05 Hrs**

**TEXT BOOKS**

1. Peters, M. S. and Timmerhaus, L. D. Plant Design and Economics for Chemical Engineering, 4th edition, McGraw-Hill International, New Delhi, 1991.
2. Banga, T. R. and Sharma, S. C. Industrial Organization and Engineering Economics, 24th edition, Khanna Publishers, New Delhi, 2011.

**REFERENCE BOOKS:**

1. Panneerselvam. R. Engineering Economics, 1st edition, PHI Learning Private Limited, New Delhi, 2013.
2. Phaneesh, K. R. Engineering Economics, 5th edition, Sudha Publications, Bangalore, 2013.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VIII Cluster CHEMICAL**

<b>Subject</b>	<b>Non-conventional Energy Technology</b>										<b>Credits</b>	<b>3</b>		
<b>Sub.Code</b>	<b>1</b>	<b>3</b>	<b>C</b>	<b>H</b>	<b>8</b>	<b>D</b>	<b>C</b>	<b>N</b>	<b>E</b>	<b>T</b>	<b>L-T-P</b>	<b>3</b>	<b>0</b>	<b>0</b>

**Course Outcome**

- CO 1. Familiarize with the various forms of energy resources and its global distribution with its environmental impacts.
- CO 2. Familiarize the various non-conventional energy resources and design requirements for its economical utilization.
- CO 3. Design basic aspects to establish non-conventional energy harvesting units.

**UNIT I**

**INTRODUCTION:** Man and Energy, World's and India's production and reserves of energy, present and future power position, need for alternate energy, energy alternatives. **5Hrs**

**UNIT II**

**SOLAR ENERGY:** Introduction: Extraterrestrial solar radiation, radiation at ground level, collectors. Solar cells, applications of solar energy. **6 Hrs.**

**UNIT III**

**BIOMASS & GEOTHERMAL :** Biomass Energy. Introduction, Biomass Conversion, Biogas Production, Ethanol Production, Pyrolysis and Gasification, Direct Combustion, Applications of biomass energy.

Recovery of thermal conversion products -Combustion of waste materials & related calculations, Waste incineration with heat recovery and use of Refused Derived Fuels (RDF).

Geothermal Energy: Introduction, resource types, resource base. Applications for heating and electricity generation. **12 Hrs.**



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**UNIT IV**

**WIND AND HYDRO ENERGY SOURCES:** Introduction: Basic theory, types of turbines, applications. Hydropower: Introduction, basic concepts, site selection, types of turbines, small scale hydropower. **10Hrs**

**UNIT V**

**FUEL CELLS:** Introduction Principle and operation of fuel cells, classification and types of fuel cells and application of fuel cells. **6 Hrs**

**TEXT BOOKS:**

1. G.D.Rai ,Non-conventional energy resources.
2. B. H Khan, 'Non-conventional energy resources", Tata McGraw Hill, New Delhi
3. 'Fuel Cell Handbook', EG&G Technical Services, 7th edn., Inc. U.S. Department of Energy Office of Fossil Energy, National Energy Technology Laboratory.

**REFERENCES:**

1. Harker and Backhurst ,'Fuel and energy' ,Academic press, London 1981.
2. Harker and Allen Oliver and Boyd,'Fuel science',1972.
3. Howard S. Peavy, Donald R Rowe & George Tchobanoglous,Environmental Engineering, Me GEngg Thermodynamics raw -Hill International Editions



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
(Autonomous College under VTU )

**SEMESTER VIII Cluster CHEMICAL**

<b>Subject</b>	<b>FINAL PROJECT</b>										<b>Credits</b>	<b>12</b>
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>8</b>	<b>D</b>	<b>C</b>	<b>F</b>	<b>P</b>	<b>W</b>		

**Course Outcome**

- Co1. Design and carry out the experimental work in team in the predetermined methodology.
- CO2. Analyze and interpret the obtained data for optimum solution.
- CO3. Elucidate the short comings and identify the scope for future work.
- Co4. Communicate and publicize the deduce solutions.

The students in a group will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the seventh semester. The project group should complete the preliminary literature survey & plan of project and submit the synopsis at the end of seventh semester. The project work should be carried out and completed at the end of eighth semester, which is evaluated by a committee constituted by the HoD for assessment. One technical paper should be submitted at the end of the semester in reputed National/International journals for publications.

**SEMESTER VIII Cluster CHEMICAL**

<b>Subject</b>	<b>Industrial Trip and Related Seminar</b>										<b>Credits</b>	<b>2</b>
<b>Sub.Code</b>	<b>1</b>	<b>1</b>	<b>C</b>	<b>H</b>	<b>8</b>	<b>D</b>	<b>C</b>	<b>I</b>	<b>T</b>	<b>S</b>		

**Course Outcome**

- Co1. Correlate the theoretical knowledge with the real world practices.
- Co2. Communicate & report the industrial practices through technical presentations.



**B.M.S COLLEGE OF ENGINEERING, BANGALORE-19**  
**(Autonomous College under VTU )**

The students are expected to undergo in-plant training in any chemical industry or in a reputed research laboratory with pilot plant facility. This shall be for a minimum period of two weeks during the vacation of sixth & seventh semester. If it is not possible, the students may be permitted to go on industrial visit and they should visit minimum of five major chemical industries. The student should submit a report separately, at the beginning of the eighth semester<sub>1</sub>, which is evaluated by a committee constituted by the HoD for internal assessment.