17CHX29 BIOENERGY TECHNOLOGIES					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**		**Related Program outcomes**	
1.0	To know about fundamental knowledge on classification, characterization and sources of biomass	1.1	The Students will be able to understand the fundamental knowledge on classification, characterization and sources of biomass	a, b, c, d, g	
2.0	To learn about the production of biogas	2.1	The Students will be able to learn the production of biogas	a, b, c, d,	
3.0	To gather knowledge about the operations of incineration and pyrolysis.	3.1	The Students will be able to gather knowledge on the operations of incineration and pyrolysis.	a, b, c, d, f, g	
4.0	To learn about the gasification of biomass	4.1	The Students will be able to learn the gasification of biomass	a, b, c, d, f, g	
5.0	To gain knowledge about the types of combustion of biomass	5.1	The Students will be able to knowledge on the types of combustion of biomass.	a, b, c, d, f, g	

UNIT I: BIOMASS SOURCES AND CLASSIFICATION	**9**
Biomass characteristics & preparation; Chemical composition and properties of biomass; Size reduction, Briquetting of loose biomass, Drying, Storage and handling of biomass.	
UNIT II: BIOGAS TECHNOLOGY	**9**
Feedstock for producing biogas; Microbial and biochemical aspects and operating parameters for biogas production, Kinetics and mechanism. Dry and wet fermentation. Digestors for rural application-High rate digesters for industrial waste water treatment.	
UNIT III: PYROLYSIS AND THERMO-CHEMICAL CONVERSION	**9**
Thermo-chemical conversion of lignocellulosic biomass. Incineration for safe disposal of hazardous waste, Biomass processing for liquid fuel production, Pyrolysis of biomass-pyrolysis regime, effect of particle size, temperature, and products obtained.	
UNIT IV: GASIFICATION OF BIOMASS	**9**
Thermochemical principles: Effect of pressure, temperature and introducing steam and oxygen. Design and operation of Fixed and Fluidised Bed Gasifiers, Safety aspects.	
UNIT V: COMBUSTION OF BIOMASS AND COGENERATION SYSTEMS	**9**
Combustion of woody biomass-theory, calculations and design of equipment, Cogeneration in biomass processing industries. Case studies: Combustion of rice husk, Use of bagasse for cogeneration.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS

1. Anju Dahiya, Bioenergy: Biomass to biofuels First Edition, Academic Press, 2014.
2. Li, Yebo, and Samir Kumar Khanal. Bioenergy: principles and applications. John Wiley &Sons, 2016.

REFERENCES

1. Vaughn C Nelson, Kenneth L. Starcher. Introduction to bioenergy. CRC Press, 2017.
2. Wall, Judy D., Caroline S. Harwood, and Arnold Demain. "Bioenergy." Bioenergy.. ASMPress, 2008

17CHX30 RENEWABLE ENERGY RESOURCES					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To understand the fundamental knowledge on history, consumption of energy	1.1	The Students will be able to understand the fundamental knowledge on history, consumption of energy		a, b, c, d, g
2.0	To learn the production of solar energy	2.1	The Students will be able to learn the production of solar energy		a, b, c, d, f, g
3.0	To gather knowledge on the geothermal and bio energy	3.1	The Students will be able to gather knowledge on the geothermal and bio energy		a, b, c, d, g
4.0	To understand the production of wind energy and their utilization	4.1	The Students will be able to understand the production of wind energy and their utilization		a, b, c, d
5.0	To gain knowledge on the production and utilization of tidal energy	5.1	The Students will be able to knowledge on the production and utilization of tidal energy		a,b, c, d, f

UNIT I: INTRODUCTION	**9**
Past, Today, and Future. A brief history of energy consumption. Energy &Environment. Renewable Energy – Quality, quantity, availability, advantageous and limitations	
UNIT I : SOLAR ENERGY	**9**
Sun and its Energy: Basics of Solar Energy. Solar Energy in the Past. Solar ThermalEnergy Solar Photovoltaic.	
UNIT III: BIO ENERGY & GEOTHERMAL ENERGY	**9**
Conversion. Bio degradation. Biogas generation. Fuelproperties. Biomass gasifier. Geothermal Resources, Geothermal Technologies.	
UNIT IV WIND ENERGY	**9**
Wind Resources. Wind Turbines. Environmental Impact. Data and energy estimation. Conversion. Wind mill Performance and applications.	
UNIT V TIDAL ENERGY	**9**
Ocean Energy Potential against Wind and Solar. Wave Characteristics and Statistics.Wave Energy Devices. Tide Energy Technologies. Ocean Thermal Energy. Osmotic Power.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS

1. Mukherjee, D., and S. Chakrabarti. *Fundamentals of renewable energy systems*. New AgeInternational, 2004.
2. Jenkins, Nicholas, and Janaka Ekanayake. *Renewable energy engineering*. CambridgeUniversity Press, 2017

REFERENCES

1. Kishore, V. V. N., ed. *Renewable energy engineering and technology: principles andpractice*. The Energy and Resources Institute (TERI), 2010.
2. Tiwari, Gopal Nath, and Rajeev Kumar Mishra. *Advanced renewable energy sources*. RoyalSociety of Chemistry, 2012

17CHX31 ENERGY STORAGE TECHNOLOGIES					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**		**Related Program outcomes**	
1.0	to know about energy storage types and its necessity	1.1	The Students will be able to know about energy storage types and its necessity	a, b	
2.0	To know about storage of natural gases	2.1	The Students will be able to know about storage of natural gases	a, b, c, d, f, g	
3.0	To know about the storage of thermal energy	3.1	The Students will be able to know about the storage of thermal energy	a, b, c, d, f, g	
4.0	To know about the fundamental concepts of batteries	4.1	The Students will be able to know about the fundamental concepts of batteries	a, b, c, d, f, g	
5.0	To know about the various types of fuel cells	5.1	The Students will be able to know about the various types of fuel cells	a, b, c, d, f	

UNIT I: INTRODUCTION	**9**
The necessity of energy storage - types of energy storage - comparison of energy storage technologies – Applications.	
UNIT II NATURAL GAS STORAGE	**9**
General consideration, petroleum product storages, LPG storages, LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages – underground storages–loading and unloading facilities–drum and cylinder storage – warehouse, storage hazard assessment of LPG and LNG	
UNUT III: THERMAL STORAGE	**9**
Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units -Modelling using the porous medium approach.	
UNIT IV: THE FUNDAMENTAL CONCEPT OF BATTERIES	**9**
measuring of battery performance, charging and discharging of a battery, storage density, energy density, Free energy, theoretical cell voltage, specific capacity, specific energy, energy density, memory effect, cycle life, shelf life, state of charge (SOC) and depth of discharge (DOD), internal resistance and Coloumbic efficiency and safety issues. Types of batteries – Primary and secondary batteries -Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery	

UNIT V	FUEL CELL	9
History of the Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantage and drawback of each type.		
		TOTAL (L:45) : 45 PERIODS

TEXTBOOKS:

1. Energy Storage - Technologies and Applications by Ahmed Faheem Zobaa, InTech.
2. Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, New York,
3. Handbook of battery materials by C. Daniel, J. O. Besenhard,Wiley VCH Verlag GmbH & Co. KgaA
4. Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.
5. Thermal energy storage: Systems and Applications by Dincer I. and Rosen M. A., Wiley pub.

REFERENCES

1. Energy Storage: Fundmentals, Materials and Applications, by Huggins R. A., Springer
2. Fuel cell Fundamentals by R. O'Hayre, S. Cha, W. Colella and F. B. Prinz, Wiley Pub.
3. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.
4. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
5. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science
6. Compressed air energy storage by F. P. Miller, A. F. Vandome, M. B. John, VDM publishing

17CHX32 HYDROGEN AND FUEL CELL TECHNOLOGY					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To aware of alternate energy sources and its importance of it.	1.1	The Students will be able to aware of alternate energy sources and its importance of it.		a, b, c
2.0	To understand about the fuel cell kinetics	2.1	The Students will be able to understand the fuel cell kinetics		a, b, c f, g
3.0	To understand about the fuel cell characterization techniques	3.1	The Students will be able to able to understand the characterization techniques		a, b, c, d, f
4.0	To analyze about the renewable energy sources and storage	4.1	The Students will be able to analyze the renewable sources and storage		a, b, c, d, f, g
5.0	To understand about the applications of fuel cells in various fields.	5.1	The Students will be able to understand the applications of fuel cells in various fields.		a, b, c, d, f

UNIT I: INTRODUCTION	**9**
Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work Potentials, prediction of reversible voltage, fuel cell efficiency, Types of fuel cells.	
UNIT II: FUEL CELL KINETICS	**9**
Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte	
UNIT III: CHARACTERIZATION TECHNIQUES	**9**
Fuel cell characterization in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models.	
UNIT IV: RENEWABLE SOURCES	**9**
Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.	
UNIT V APPLICATIONS OF FUEL CELL	**9**
Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications	
TOTAL (L:45) : 45 PERIODS	

TEXTBOOKS

1. Gregor Hoogers, “Fuel Cell Technology Handbook”, CRC Press, 2003.
2. R.P. O'Hayre,S. Cha, W. Colella, F.B. Prinz, “Fuel Cell Fundamentals”, Wiley, 2006.
3. A. J.Bard, L. R. Faulkner, “Electrochemical Methods”, Wiley, 2004.

REFERENCES

1. S. Basu, “Fuel Cell Science and Technology”, Springer, 2007.
2. H. Liu, “Principles of Fuel Cells”, Taylor & Francis, 2006.

17CHX33 POWER PLANT ENGINEERING					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To understand the fundamental knowledge on components, layouts and working of power plants	1.1	The Students will be able to understand the fundamental knowledge on components, layouts and working of power plants		a, b, c
2.0	To learn about the types, classification and usage of boilers	2.1	The Students will be able to learn the types, classification and usage of boilers		a, b, c, f, g
3.0	To gather knowledge on classification and usage of steam turbines	3.1	The Students will be able to gather knowledge on classification and usage of steam turbines		a, b, c, f
4.0	To understand about the types of gas turbines	4.1	The Students will be able to understand the types of gas turbines		a, b, c, g
5.0	To gain knowledge on the application of integration of various process in power plants	5.1	The Students will be able to knowledge on the application of integration of various process in power plants		a, b, c

UNIT I	**9**
Power Plants - Features, Components and Layouts - Working of Power Plants. Power PlantEconomics.	
UNIT II	**9**
Boiler Classification - Boiler Types - Fire Tube & Water Tube Boilers - Fluidized Bed Boilers - Positive Circulation Boilers - Thermal Liquid Heaters & Vaporizers	
UNIT III	**9**
Steam Turbines: Classification - Features - Working – Performance; Losses in Steam Turbines - Trouble Shooting	
UNIT IV	**9**
Gas Turbines: Classification and Comparison of Different Types Gas Turbine Power Plants Components - Economics & Future of Combined Cycles	

UNIT V	9
Integrated Gasification Combined Cycle (IGCC) – Indirect Fired Combined Cycle (IFCC) – Magneto Hydrodynamics (MHD) – Fuel Cells – Micro turbines– RDF based power plants.	
	TOTAL (L:45) : 45 PERIODS

TEXT BOOKS

1. Thomas C. Elliott ,"Standard Hand Book of Power Plant Engineering"
2. L.C.Witte, P.S.Schmidt, D.R.Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988.

REFERENCES

1. E L Wakil, "Power Plant Engineering", McGraw-hill Book Co, N.Y. 2001
2. Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Ra, N.Delhi.2003
3. Nag, P.K., "Power Plant Engineering", 2 nd Edition, TMH, 2001

17CHX34 NON-RENEWABLE ENERGY SOURCES

L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

	Course Objectives		Course Outcomes	Related Program outcomes
1.0	To understand the fundamental knowledge on petroleum and its products	1.1	The Students will be able to understand the fundamental knowledge on petroleum and its products	a, b, c
2.0	To learn the usage of coal, types and its composition	2.1	The Students will be able to learn the usage of coal, types and its composition	a, b, c, f, g
3.0	To gather knowledge on the properties, classification and products of natural gas	3.1	The Students will be able to gather knowledge on the properties, classification and products of natural gas	a, b, c, f, g
4.0	To understand the fundamentals of nuclear engineering	4.1	The Students will be able to understand the fundamentals of nuclear engineering	a, b, c, g
5.0	To gain knowledge on the usage of nuclear reactors, nuclear waste management and safety usage	5.1	The Students will be able to knowledge on the usage of nuclear reactors, nuclear waste management and safety usage	a, b, c

UNIT I: INTRODUCTION
Origin of Petroleum, Composition, Extraction of Petroleum. Products of Petroleum refining: Diesel; Gasoline; LPG; Fuel oil; Tar; and Bitumen. Environmental issues associated with petroleum resources.
UNUT II: TYPES OF COAL
Composition of coal; Oxygen conten, Proximate and Ultimate Analysis of coal; Carbonization, Coal for generation of electricity, coal liquefaction, coal blending. Environmental issues associated with usage of coal
UNIT III: NATURAL GAS
Resources of for Natural Gas, Properties and classification of natural gas, transporation of natural gas, products from natural gas, liquefied natural gas, chemicals from natural gas, shale gas; Environmental Issues associated with usage of coal.
UNIT IV: NUCLEAR ENGINEERING FUNDAMENTALS
Nuclear models, binding energy, Radio activity, half-life, mechanism of nuclear fission and fusion, decay chains, neutron reactions. Nuclear Fuels; Nuclear fuel reserves of Uranium and Thorium, Nuclear fuel cycles, characteristics, production and purification, other fuels Zirconium, Beryllium.
UNIT V: NUCLEAR ENERGY
Nuclear reactors and classification, boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of nuclear fusion reactor. Nuclear Power Plant -Waste Management and Safety
TOTAL (L:45) : 45 PERIODS

TEXT BOOKS

1. Breeze, Paul. Nuclear power. Academic Press, 2016.
2. Viswanathan, Balasubramanian. Energy sources: fundamentals of chemical conversionprocesses and applications. Newnes, 2016.
3.

REFERENCE

1. Rao, S., and B. B. Parulekar. "Energy Technology: Non-conventional, Renewable andConventional. " Khanna Publication, 3rd (2012

17CHX35 ENERGY MANAGEMENT					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**		**Related Program outcomes**	
1.0	To acquire the need of energy conservation	1.1	The student will be able to acquire the need of energy conservation	a, b, c	
2.0	To analyze types and objectives of energy auditing	2.1	The student will be able to analyze types and objectives of energy auditing	a, b, c, f, g	
3.0	To analyze the methods for reactive power compensation	3.1	The student will be able to analyze the methods for reactive power compensation	a, b, c, f	
4.0	To analyze tools for economics of energy conservation	4.1	The student will be able to analyze tools for economics of energy conservation	a, b, c, g	
5.0	To analyze the ECO (Energy Conservation opportunity) in mechanical systems such as boilers, pumps, compressors, water heaters etc.	5.1	The student will be able to analyze the ECO (Energy Conservation opportunity) in mechanical systems such as boilers, pumps, compressors, water heaters etc.	a, b, c, g	

UNIT I	**9**
Importance of energy management, electric energy conservation Energy auditing – methodology, System approach and End-use approach to efficient use of Electricity, Electricity tariff types, Types and objectives, audit instruments, specific energy analysis, Minimum energy paths, consumption models, Case study. Demand-side management.	
UNIT II	**9**
Electric motors- Energy efficient controls and starting -Motor Efficiency and Load Analysis- Energy-efficient motors-Case study; Load Matching and selection of motors-Variable speed drives.	
UNIT III	**9**
Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses- Location-Placement Maintenance, case study. Peak Demand controls Methodologies- Types of Industrial loads-Optimal Load scheduling-case study.	
UNIT IV	**9**
ECO assessment and Economic methods- Simple payback period- time value of money-Net Present value-Internal rate of return Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues Luminaries, case study.	

UNIT V	9
Power Consumption in Compressors, Energy conservation measures. Water heating-Gysers-Solar Water Heaters- solar PV Systems.	
	TOTAL (L:45) : 45 PERIODS

TEXT BOOKS

1. Guide Book for National Certification Examination for Energy Managers & Energy Auditors – Bureau of Energy Efficiency, Ministry of Power, Govt of India.
2. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006
3. Utilization, Generation & Conservation of Electrical Energy, Sunil S.Rao, Khanna publishers, 2007.

REFERENCES

1. Anthony J. Pansini, Kenneth D. Smalling, Guide to Electric Load Management., Pennwell Pub; (1998)
2. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975
3. Tripathy S.C., 'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991

17CHX36 THERMAL ENERGY CONSERVATION TECHNIQUES					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To learn about the basics of Energy and its various forms	1.1	The student will be able to understand the Principles of energy conservation and management		a, b, c
2.0	To Learn the present energy scenario and the need for energy conservation	2.1	The student will be able to Execute thermal energy auditing.		a, b, c, f, g
3.0	To Study the different measures for energy conservation and financial implications of various thermal utilities	3.1	Discuss financial aspects as far as Energy Conservation Schemes are concerned.		a, b, c, f
4.0	To Understand the energy crisis and environmental concerns associated with energy management, and the importance of energy conservation,	4.1	Apply the scientific knowledge for energy conservation and management in the thermal energy systems		a, b, c, f, g
5.0	To Apply energy conservation techniques in thermal systems	5.1	Discuss the most used energy planning and management systems		a, b, c, f

UNIT 1:	**9**
Basics of Energy and its various forms, Primary/Secondary Energy Sources, Energy crisis and environmental concerns, Principles of energy conservation and management, Energy Conservation, Energy Intensive Industries, Barriers, Energy Conservation Acts - Salient Features, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Integrated energy policy, National action plan on climate change.	
UNIT II:	**9**
Energy audit, definition, need, types of the energy audit, Energy management (audit) approach - understanding energy costs, benchmarking, energy performance, optimizing the input energy requirements, energy audit instruments and metering, smart metering, Roles and responsibilities of an energy manager, Financial Analysis Techniques, CUSUM Technique, Energy Management Information Systems (EMIS), ESCO Concept, ESCO Contracts.	
UNIT III:	**9**
Energy conservation in boilers-Types of fuel used - properties of fuel- oil, coal and gas. Stoichiometry, Boiler efficiency-performance of a boiler, Heat Loss Estimation, Steam Traps, Steam Piping & Distribution. Thermic Fluid Heaters – Insulation & Refractories.	

UNIT IV:	9
Cogeneration – Principles & Operation, Power Ratio, Economics of Cogeneration Scheme, Case Study on Cogeneration, WHR – Sources & Grades, Types (Heat Wheel, Recuperators, Regenerators, Heat Pipe etc), Scheme Evaluation, Economics of WHR Systems. Thermal Energy Storage – Basics & Concepts as an ENCON scheme.	
UNIT V:	**9**
Energy conservation in refrigeration and air conditioning systems- EER / SEC Evaluation –. Types & Applications of Cooling Towers, Basics, Performance Analysis. DG Set – Performance Prediction, Cost of Power Generation. Energy conservation in Cooling Towers and DG set.	
TOTAL (L:45) : 45 PERIODS	

TEXTBOOKS

1. Diamant R.M.E., Total Energy, Pergamon, Oxford, 1970.
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case study, Hemisphere, Washington, 1980.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Trivedi P.R., Julka K.R., Energy Management, Commonwealth Publication, New Delhi, 1997

REFERENCES

1. Practical guide to energy conservation – a ready reckoner on energy conservation measures; Petroleum Conservation Research Association, 2009.
2. Reay D. Industrial energy conservation, Pergamon Press, 1979.
3. White L. C., Industrial Energy Management and Utilization; Hemisphere Publishers, 1988.
4. Eastop T. D. and Croft D. R., Energy Efficiency for Engineers and Technologists, Longman- Scientific and Technical Series, 1988.

17CHX37 BIOCHEMISTRY					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**		**Related Program outcomes**	
1.0	To understand the basic concepts on carbohydrates.	1.1	The Students will be able to understand the basic concepts on carbohydrates.	a, b, c, d	
2.0	To learn the concepts of proteins	2.1	The Students will be able to learn the concepts of proteins	a, b, c, d	
3.0	To gather knowledge on importance of nucleic acids	3.1	The Students will be able to gather knowledge on importance of nucleic acids	a, b, c, d	
4.0	To understand the knowledge on lipids	4.1	The Students will be able to understand the knowledge on lipids	a, b, c, d	
5.0	To gather knowledge on intermediary metabolism and their pathways	5.1	The Students will be able to gather knowledge on intermediary metabolism and their pathways	a, b, c, d	

UNIT I: INTRODUCTION TO BIOMOLECULES AND CARBOHYDRATES	**9**
Basic principles of organic chemistry, role of carbon types of functional groups, chemical, natureof water, pH and biological buffers, bio molecules structure and properties of Carbohydrates mono, di, oligo & polysaccharides) Proteoglycans, glucosaminoglycans. mutarotation, glycosidic bond, reactions of monosaccharides, reducing sugars. Starch, glycogen, cellulose and chitin. Proteoglycans, glycosaminoglycans. hyaluronic acid, chondroitin sulfate	
UNIT II STRUCTURE AND PROPERTIES OF OTHER BIOMOLECULES	**9**
Structure and properties of Important Biomolecules. **Lipids:** fatty acids, glycerol, saponification, iodination, hydrogenation, phospholipids, glycolipids, sphingolipids, cholesterol, steroids, prostaglandins. **Protein:** Amino Acids, Peptides, Proteins, measurement, structures, hierarchy of organizationprimary, secondary, tertiary and quaternary structures, glycoproteins, lipoproteins. Determine of primary structure. **Nucleic acids:** purines, pyrimidines, nucleoside, nucleotide, RNA, DNA-Watson-Crick structure of DNA, reactions, properties, measurement, nucleoprotein complexes	
UNIT III: METABOLISM CONCEPTS AND CARBOHYDRATE METABOLISM	**9**
Functions of Proteins, Enzymes, introduction to biocatalysts, metabolic pathways, primary and secondary metabolites. Interconnection of pathways and metabolic regulation. Glycolysis, TCA cycle, gluconeogenesis, pentose phosphate shunt & glyoxalate shunt	

UNIT IV: INTERMEDIARY METABOLISM AND REGULATION	9
Fatty acid synthesis and oxidation, reactions of amino acids, deamination, transamination and decarboxylation, urea cycle, Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.	
UNIT V: PROTEIN TRANSPORT AND DEGRADATION	9
Protein targeting, signal sequence, secretion; Folding, Chaperone and targeting of organelle proteins, Protein degradation, receptor-mediated endocytosis, turnover	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS

1. Lehninger Principles of Biochemistry 6th Edition by David L. Nelson, Michael M. CoxW.H.Freeman and Company 2017
2. Satyanarayana, U. and U. Chakerapani, "Biochemistry" 3rd Rev. Edition, Books & Allied(P) Ltd., 2006.
3. Rastogi, S.C. "Biochemistry" 2nd Edition, Tata McGraw-Hill, 2003.
4. Conn, E.E., etal., "Outlines of Biochemistry" 5th Edition, John Wiley & Sons, 1987.
5. Outlines of Biochemistry, 5th Edition: By E E Conn, P K Stumpf, G Bruening and R Y Doi. pp693. John Wiley and Sons, New York. 1987.

REFERENCES

1. Berg, Jeremy M. et al. "Biochemsitry", 6th Edition, W.H. Freeman & Co., 2006.
2. Murray, R.K., etal "Harper's Illustrated Biochemistry", 31st Edition, McGraw-Hill, 2018.
3. Voet, D. and Voet, J.G., "Biochemistry", 4th Edition, John Wiley & Sons Inc.,2010.

17CHX38 BIOPROCESS PRINCIPLES AND TECHNOLOGY					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To understand the fundamental knowledge on bioprocess technology	1.1	The Students will be able to understand the fundamental knowledge on bioprocess technology		a, b, c, d
2.0	To learn the production process of biomolecules	2.1	The Students will be able to learn the the production process of biomolecules		a, b, c, d
3.0	To gather knowledge on the operations of bioreactors and their purposes	3.1	The Students will be able to gather knowledge on the operations of bioreactors and their purposes		a, b, c, d, g
4.0	To understand the transportation processes in reactors and their behaviors	4.1	The Students will be able to understand the transportation processes in reactors and their behaviors		a, b, c, d, g
5.0	To knowledge on the biosafety and information on bioethics	5.1	The Students will be able to knowledge on the biosafety and information on bioethics.		a, b, c, d, h

UNIT I: INTRODUCTION TO BIOPROCESS	9
Biologists and Engineers, comparison of chemical and biochemical processing overview of biological basics, About cells and its growth, the stoichiometry of microbial growth and product Bioprocesses: Regulatory Constraints	
UNIT II: MEDIA FORMULATION AND DEVELOPMENT	9
Media formulation, Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, solid and liquid handling. Industrially fermented broth	
UNIT III: UNDERSTANDING BIOREACTORS	9
Purpose and importance of bioreactors, Classification of bioreactors, bioreactors for animal cells, bioreactors for plant cells, bioreactors for immobilized cells, operations of bioreactors, stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, airlift reactor, Agitation, and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, bioreactors for waste management	

UNIT IV: TRANSPORT PROCESSES	9
Aspects of rheology, Fluid flow in packed-bed and Fluidized bed columns, Gas-liquid mass transfer in cellular systems Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion, mass transfer coefficient, macroscopic balances for mass transport. Mechanisms and applications of heat transfer-mode of heat transfer-conduction, convection and radiation, Application of Heat and Mass transfer in biochemical processes.	
UNIT V: BIOETHICS AND BIOSAFETY	9
Introduction to Bioethics. Social and ethical issues, the process of biotechnology involved ingenerating new forms of life for informed decision making, Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release into the environment.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York,McGraw-Hill, 1986.
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.
3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science &Technology Books. 1995

REFERENCES

1. Transport Phenomena, by Bird R.B., Steward W.E., and Lightfoot E.N., John Wiley &sons, Inc., New York, 2002
2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition,New Jersey, PHI Publishers, 2010

17CHX39 FERMENTATION AND BIOPROCESSING					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To understand the structural, functional properties of microbes	1.1	The Students will be able to understand the structural, functional properties of microbes		a, b, c, d
2.0	To learn the growth kinetics of microorganisms	2.1	The Students will be able to learn the growth kinetics of microorganisms		a, b, c, d
3.0	To understand the basic concepts in designing of fermenters	3.1	The Students will be able to understand the basic concepts in designing of fermenters		a, b, c, d, g
4.0	To gather knowledge on the operation of control systems in fermentation and bioprocess industry	4.1	The Students will be able to gather knowledge on the operation of control systems in fermentation and bioprocess industry		a, b, c, d, e
5.0	To acquire knowledge on the commodity, fermentation production and their production pathways	5.1	The Students will be able to acquire knowledge on the commodity, fermentation production and their production pathways		a, b, c, d, e

UNIT I FERMENTATION PROCESSES	**9**
Importance of fermentation, Fermentation and redox potential, solid-liquid fermentation, solid state fermentation, Kinetics of fermentations, Biosensors for fermentations, Production processes in fermentation.	
UNIT II: MICROBIAL GROWTH KINETICS	**9**
Diversity of patterns of microbial growth in situ and ex situ, Microbial growth under homogeneous conditions, Heterogeneous microbial growth, Growth kinetics, Derivation of mathematical models, and identification	
UNIT III: DESIGN OF FERMENTERS	**9**
Fermentation processes, Fermentation processes and microorganisms, Kinetics and stoichiometry, Mass balances and design for batch, continuous and fed-batch reactors, Comparison of batch, continuous and fed-batch reactors, Heat generation and heat balances, examples of industrial fermentation processes	
UNIT IV INSTRUMENTATION AND CONTROL	**9**
Common Instruments for Process Automation — Temperature, Gas Flowrate, Liquid Flowrate, Off- Gas Analysis, pH, Dissolved Oxygen, Pressure, Foam Level, Stirring , Redox Potential, Advanced Instrumentation for Bioprocess Control and Automation - Flow Injection Analysis, Sequential Injection Analysis Fluorescence, Mass Spectrometry, Near Infrared Spectroscopy, Soft sensors, Biomass, Bioreactor automation	

UNIT V: FERMENTATION AND COMMODITY PRODUCTS	9
Engineering of Secretory Pathways, production of heterologous proteins, fungal, yeast fermentation of industrial products.	
	TOTAL (L:45) : 45 PERIODS

TEXTBOOKS:

1. Essentials in Fermentation Technology, Aydin Berenjian, Springer ,2019.
2. Principles of Fermentation Technology (Second Edition), Peter F. Stanbury, Allan Whitakerand Stephen J. Hall, Pergamon, 1995

REFERENCES:

1. Fermentation and Biochemical Engineering Handbook; Editors-in-Chief: Henry C. Vogeland Celeste M. Todaro, Third Edition, Elsevier, 2014.
2. Fermentation Biotechnology: Principles, Processes, and Products (Prentice Hall advancedreferences series), Owen P. Ward, Prentice Hall, 1989

17CHX40 BIOSEPERATION AND DOWNSTREAM PROCESSING

L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

	Course Objectives		Course Outcomes	Related Program outcomes
1.0	To understand the basic concept of bio separation processes	1.1	The Students will be able to understand the basic concept of bio separation processes	a, b, c, d
2.0	To acquire knowledge on theory, design, and application of bioprocessing	2.1	The Students will be able to acquire knowledge on theory, design, and application of bioprocessing	a, b, c, d, g
3.0	To understand the basic concepts absorption and their problems in bioprocessing	3.1	The Students will be able to understand the basic concepts absorption and their problems in bioprocessing	a, b, c, d, g
4.0	To understand the basic concepts absorption and their problems in bioprocessing	4.1	The Students will be able to gather knowledge on extraction of bioproducts using different methods	a, b, c, d, e
5.0	To acquire knowledge on chromatography techniques and their analysis, membrane separation process	5.1	The Students will be able to acquire knowledge on chromatography techniques and their analysis, membrane separation process	a, b, c, d, e

UNIT I : INTRODUCTION	9
Introduction to By-products and Bioseparation: Range and characteristics of bio products, Characteristics of Fermentation Broth, Selection of unit operation with due consideration of the physical, chemical and biochemical aspects of biomolecules. Stages of Downstream Processing	
UNIT II: CENTRIFUGATION AND FILTRATION	9
Primary Separation: Removal of insoluble and Biomass (and particulate debris) separation techniques, Flocculation and sedimentation, Centrifugation-Ultracentrifugation, Gradient centrifugation, Filtration: Theory of Filtration, Pre-treatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes	
UNIT III: ABSORPTION	9
Gas Absorption: Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liq ratio, Single stage gas absorption Cross Current, Co- current, Countercurrent, Multistage Counter current Operation, Absorption with Chemical Reactions, Related problems	

UNIT IV: EXTRACTION	9
Liquid-Liquid Separation Process: Single Stage Operation, Equipments for liquid-liquid extraction. Types of extraction processes: Reactive extraction, Aqueous two-phase systems, Reverse micellar extraction, solid-liquid extraction, Supercritical fluid Extraction. Different types of extractors and designing of extractors. Distillation: Simple, Steam and Equilibrium distillation, Fractionation, Mccabe Thiele method, azotropes,	
UNIT V CHROMATOGRAPHY AND MEMBRANE SEPARATION	9
Theory of chromatography, Shape and yield of a chromatographic peak, Binary chromatography, Hydrodynamic chromatography. Membrane-based bioseparation - Classification of membrane processes, Ultrafiltration, Microfiltration, Dialysis, Liquid membrane processes, Membrane chromatography, Electrophoresis, Affinity ultrafiltration, Field-flow fractionation	
TOTAL (L:45) : 45 PERIODS	

TEST BOOKS:

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. Roger G. Harrison, Paul Todd, ScottR. Rudge, Demetri P. Petrides, Bioseparations Scienceand Engineering, Oxford University Press
3. B.Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHILearning Pvt. Ltd., Publishing House, New Delhi, 2012
4. Bioseparation & bioprocessing (2nd Ed) 2-Volume set, Ed SUBRAMANIAN Ganapathy,Wiley-VCH, (09-2007)

REFERENCES:

1. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
2. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.Scopes Ak, Protein Purification, IRL Press, 1993
3. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
4. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989

17CHX41 ENZYME IMMOBILISATION TECHNOLOGY					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**		**Related Program outcomes**	
1.0	To understand the basic knowledge on classification of enzymes and their nomenclature	1.1	The Students will be able to understand the basic knowledge on classification of enzymes and their nomenclature	a, b, c, d	
2.0	To understand Enzymes, homogeneity, and heterogenicity	2.1	The Students will be able to understand Enzymes, homogeneity, and heterogenicity	a, b, c, d,	
3.0	To understand structural, functional properties, and metabolic pathways of enzymes	3.1	The Students will be able to understand structural, functional properties, and metabolic pathways of enzymes	a, b, c, d, g	
4.0	To learn immobilization procedures, and their different types.	4.1	The Students will be able to learn immobilization procedures, and their different types.	a, b, c, d, g	
5.0	To knowledge on designing enzyme reactors.	5.1	The Students will be able to understand the designing of enzyme reactors.	a, b, c, d, e	

UNIT I : INTRODUCTION	**9**
Catalysis and biocatalysis, Enzyme classification and nomenclature, enzyme structure, functionality and relationship, enzyme activity, enzyme sources, synthesis, recovery and purification, enzymes as process catalysts.	
UNIT II: HOMOGENEOUS ENZYME KINETICS	**9**
Hypothesis of enzyme kinetics, rapid equilibrium and steady-state hypothesis, determination of kinetic parameters, various types of kinetic inhibition, reactions with more than one substrate, effect of environmental variables- pH, temperature, and ionic strength.	
UNIT III: BASICS OF IMMOBILISATION	**9**
Immobilisation – Functional properties, Classification of Immobilisation techniques– Adsorption, matrix entrapment, crosslinking, covalent binding- advantages & disadvantages of each method, selection and characterisation of matrices for immobilisation, effect of physico chemical parameterson immobilised enzymes.	
UNIT IV: HETEROGENEOUS ENZYME KINETICS	**9**
Mass transfer effects in heterogeneous biocatalysis, partition effects, Immobilised enzyme kinetics-external (film) diffusion, internal (pore) diffusional kinetics, Thiele modulus and Effectiveness factor. Effects of electrostatic potential of the micro environment.	

UNIT V	ENZYME REACTORS & APPLICATION OF IMMOBILISED ENZYMES	9
Design of reactors with immobilised enzymes, Design of advanced immobilized enzyme systems, Application of immobilised enzymes in food industry, textile industry, Pharmaceutical industry & in medicine, in the production of biofuels, detergent industry, production of various bio-products, as biosensors		
		TOTAL (L:45) : 45 PERIODS

TEXT BOOKS:

1. "Enzyme Technology" by M.F.Chaplin and C.Bucke, Cambridge University press, 1990.(Website for the book, www:lsbu.ac.uk/biology/enztech/)
2. "Biocatalysts and Enzyme Technology" by K. Buchholz,V. Kasche and U.T. Bornscheur, Wiley,2005

REFERENCES:

1. "Enzyme Technology", by Shanmugam,S. and Satish Kumar,T.,IK International Pvt. Ltd,New Delhi, 2008
3. Enzyme Biocatalysis: Principles and Applications' by A.Illanes, Springer,2008

17CHX42 BIOREACTOR DESIGN					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To compare kinetics and reaction rates for various bioreactor designs, based on operational mode and type of substrate.	1.1	The Students will be able to compare kinetics and reaction rates for various bioreactor designs, based on operational mode and type of substrate.		a, b, c, e
2.0	To differentiate and estimate productivity in commercial bioreactors- packed bed, fed batchreactors	2.1	The Students will be able to differentiate and estimate productivity in commercial bioreactors- packed bed, fed batch reactors		a, b, c, d, e, f, g
3.0	To helps to understand various requirements such as material of construction, valves, agitator, sensors etc	3.1	The Students will be able to helps to understand various requirements such as material of construction, valves, agitator, sensors etc		a, b, c, d, e, g
4.0	To understanding the mechanical design and heat transfer calculations for various type of bioreactor	4.1	The Students will be able to understanding the mechanical design and heat transfer calculations for various type ofbioreactor		a, b, c, d, e
5.0	To analyze immobilization techniques in reactors and use it for various applications	5.1	The Students will be able to analyze immobilization techniques in reactors and use it for various applications		a, b, c, d, e

UNIT I BIOREACTOR DESIGN & MEDIA REQUIREMENTS	**9**
Microbial growth and product formation kinetics, Bioreactor Selection, Reactor operational mode and selection.	
UNIT II: DESIGN EQUATIONS FOR BIOREACTORS	**9**
Basic Design Equations/ Mole Balances: Batch, Fed-Batch and Repetitive Batch Reactors, Continuous: Stirred tank and tubular flow reactors, Microbial death kinetics, Design criterion for sterilization, Batch and continuous sterilization of medium, Multiple reactions-series, parallel and mixed-mode, Air sterilizatio	
Unit III: BIOREACTOR REQUIREMENTS	**9**
Process-General requirements; Basic design and construction of bioreactors and their ancillaries; Material of construction, Vessel geometry, Bearing Assemblies, Motor drives, Aseptic seals; Flow measuring devices, Valves, Agitator and Sparger Design, Sensors Non-isothermal homogeneous reactor systems. Adiabatic reactors, batch and continuous reactors, optimum temperature progression	

UNIT IV: DESIGN OF BIOREACTORS	9
Process and mechanical design of Bioreactors, volume, sparger, agitator-type, size and motor power, heat transfer calculations for coil and jacket, sterilization system, scale-up, scale down, bioinstrumentation and control.	
UNIT V NOVEL BIOREACTORS DESIGN	9
Design of Immobilized enzyme packed bed Reactor. Fluidized bed reactors, Slurry Reactors, Airlift & Loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; SSF bioreactors. bioreactor design considerations for plant and animal cell cultures.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Bioprocess Engineering -Kinetics, Mass Transport, Reactors and Gene Expression Wolf R.Vieth A Wiley-Interscience Publication 1994
2. Chemical Kinetic Methods: Principles of relaxation techniques Kalidas C New AgeInternational 1996
3. Chemical Reactor Analysis and Design Forment G F and Bischoff K B John Wiley 1990

REFERENCE:

1. Bioprocess Engineering -Kinetics, Biosystems, sustainability and reactor Design, Shijie Liu,Elsevier Publication 2013.

17CHX43 ENVIRONMENTAL BIOTECHNOLOGY					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To learn about environmental systems and pollutants along with the existing and emerging technologies	1.1	Students will learn about environmental systems and pollutants along with the existing and emerging technologies that are important in the area of environment biotechnology.		a, b, c, d
2.0	To understand the importance of microbial diversity and technologies	2.1	Students will understand the importance of microbial diversity and technologies for environmental sustainability and processes.		a, b, c, d
3.0	To understand principles of waste water technologies	3.1	The Students will be able to understand principles of waste water technologies and analyze case studies of the area to conceptualize a research program with an aim to solve the existing global environmental problems.		a, b, c, e, f, g
4.0	To critically analyze relevant journal articles and investigate industrial applications of the concepts of biotechnology for effluent treatment.	4.1	The Students will be able to critically analyze relevant journal articles and investigate industrial applications of the concepts of biotechnology for effluent treatment.		a, b, c, d, f, g
5.0	To learn as to how they can manipulate, enhance or retard biological processes	5.1	Students should learn as to how they can manipulate, enhance or retard biological processes for bioremediation of natural sources and xenobiotic degradation.		a, b, c, g

UNIT I: ENVIRONMENTAL SYSTEMS AND POLLUTANTS	**9**
Physical and chemical aspects of natural environmental processes, Metals and nonmetals, carcinogens, radioactive materials, and pathogens/pathogenic sample. Industrial, Municipal and agricultural waste, Handling, processing, and disposal of various hazardous and toxic materials, diversity and role of microorganisms in diverse and complex environments, Use and management of microbes for the benefit of ecosystems and society	
UNIT II: AIR POLLUTION	**9**
Dynamic nature of air quality, Ambient and industrial conditions, Principals and practices of air quality management, Air Quality Management, Air treatment technologies, Contaminant movement in air matrices, and data analysis	

UNIT III: WATER AND WASTE WATER TREATMENT	9
Water resources, drinking water standards, water quality characteristics, water pollutants, Sampling and laboratory instrument procedures, An overview of the geology, properties, flow, and pollution of ground water systems, sewage and potable water treatment plants, Unit operations, physical, chemical and biological used in waste water treatment, Design of an Effluent treatment plant, Reactors for waste water treatment	
UNIT IV: SOIL POLLUTION AND SOLID WASTE MANAGEMENT	**9**
Generation, processing, and disposal of municipal, industrial, and agricultural waste materials, technical concepts of solid waste management, Design and operation of landfills, waste-to-energy systems, composting facilities, recycling facilities, and other emerging waste management technologies.	
UNIT V POLLUTION PREVENTION	**9**
Principles of pollution prevention and environmentally conscious products, processes and manufacturing systems, Post-use product disposal, life cycle analysis, Pollution prevention economics, Overview of major environmental laws such as the Clean Air and Clean Water Acts, Regulatory issues	
TOTAL (L:45) : 45 PERIODS	
TEXTBOOKS 1. Young MM, Comprehensive Biotechnology; Pergamon Press. 2. De AK, Environmental Chemistry; Wiley Eastern Ltd.	
REFERENCES 1. Allsopp D, Seal KJ, Introduction to Biodeterioration; ELBS/Edward Arnold. 2. Metcalf, Eddy, Tchobanoglous G,Waste Water Engineering - Treatment, Disposal and Reuse; Tata McGraw Hill	

17CHX44 INDUSTRIAL BIOTECHNOLOGY					
			L	T	P	C
			3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			**Related Program outcomes**
1.0	To learn about basics of Industrial Biotechnology	1.1	The Students will be able to understand the basics of fermentation processes and metabolites.		a, b, c
2.0	To learn about the functions of microbes in Agriculture and Food Industry	2.1	The Students will be able to know about uses of Biofertilizers and biopesticides		a, b, c, f, g
3.0	To learn about the process technology for the production of cell biomass and primary metabolites	3.1	The Students will be able to understand the process technology used for the production of cell biomass and primary metabolites and its applications.		a, b, c, d, f
4.0	To learn about the microbial production of pharmaceuticals and other bioproducts	4.1	The Students will be able to understand the production of antibiotics and other bioproducts.		a, b, c, d, f
5.0	To learn about production and economics biofuels.	5.1	The Students will be able to know about the production of energy from biomass.		a, b, c, d, g

UNIT I: INTRODUCTION TO INDUSTRIAL BIOTECHNOLOGY	**9**
Overview of fermentation; solid and submerged fermentation, culture techniques batch, fed-batch and continuous; strain improvement, media optimization and types of industrial fermenter. Primary and secondary metabolites.	
UNIT II MICROBES IN AGRICULTURE AND FOOD INDUSTRY	**9**
Biofertilizers and biopesticides, SCP, microbial production of wine, beer and vinegar; biopreservatives (Nisin), cheese, biopolymers (xanthan gum, PHB etc), vitamins; Bioflavours and biopigments, microbial pigments in textile and food industry.	
UNIT III: PROCESS TECHNOLOGY FOR THE PRODUCTION OF CELL BIOMASS AND PRIMARY METABOLITES	**9**
Ethanol, acetone butanol, citric acid, dextran and amino acids. Production of enzymes and specialty chemicals: Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis, Applications of bioconversion, transformation of steroids and sterols.	
UNIT V: MICROBIAL PRODUCTION OF PHARMACEUTICALS AND OTHER BIOPRODUCTS:	**9**
Antibiotics, enzyme inhibitors and specialty chemicals; production of Vitamins, glutamic acid, L-Lysine. Biotransformation of non-steroidal compounds, antibiotics, environmental toxicants.	
UNIT VI: BIOENERGY	**9**
Fuel from biomass, production and economics of biofuels, biogas, bio-refineries, Microbial Enhanced Oil Recovery (MEOR).	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS

1. Glazer AN, Nikaido H (2007): Microbial Biotechnology: Fundamentals of Applied Microbiology
2. Wulf Cruger and Anneliese Crueger (2003), Biotechnology: A Textbook of Industrial Microbiology, Panima Publishing Corporation.
3. Malden MA (2001): Industrial Microbiology: An introduction; Blackwell Science (2001)

REFERENCES

1. H.W. Blanch, S. Drew, D.I.C.Wang and M. Moo-Young, Comprehensive Biotechnology: The Practice of Biotechnology: Current Commodity Products, Pergamon Press (1985).
2. C. Vogel and C.L. Tadaro, Fermentation and Biochemical Engineering Handbook: Principles, Process, Design and Equipment, Noyes Publications (1996).
3. P.F. Stansbury and A. Whitaker, Principles of Fermentation Technology: An Introduction to Current Concepts, Pergamon Press (1993).

17CHM01 FUNDAMENTALS OF CHEMICAL ENGINEERING				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To understand the basic concepts of chemical process industries	1.1	Understand the concepts of unit operations and unit processes.	A,b,d,f,g,h
2.0	To learn the fundamentals of mechanical operations and their significance in chemical industries	2.1	Apply the principles of size reduction, separation and transportation for handling solids in Chemical process industries.	A,b,c,d,f,g,h
3.0	To gain exposure over fluid properties and types of fluids	3.1	Comprehend the importance of fluid properties, types of fluids and select the manometers for pressure measurement	A,b,c,g
4.0	To understand the heat transfer mechanisms and the types of heat exchange equipments	4.1	Familiarize with modes of heat transfer and acquire knowledge on types of heat exchangers.	A,b,c
5.0	To have a basic idea on process calculations carried out in chemical industries.	5.1	Understand and apply the concepts of units and dimensions, mole, weight percentage, mole percentage in process calculations.	A,b,c,e,g

UNIT I : BASICS OF CHEMICAL PROCESS INDUSTRIES	(9)
Unit process and unit operations concepts-Outlines of unit process- Calcination, Carbonylation, Combustion, Hydration, Dehydration, Hydrolysis, Nitration, Sulfonation, Polymerization.	
UNIT II : FUNDAMENTALS OF MECHANICAL OPERATIONS	(9)
Size reduction-Crushing and grinding, Equipments and Uses- Solid -fluid separations, Equipment and industrial uses, Gas-solid separations-Equipment and industrial uses. Solid handling-conveyors types and uses.	

UNIT III : FUNDAMENTALS OF FLUID MECHANICS	(9)
Definition of fluids-compressible and incompressible fluids-Physical properties of fluids-density, specific weight, specific volume, viscosity-Compressible fluids and incompressible fluids-ideal and real fluids-Pressure Measurement Manometers-U-tube manometer.	
UNIT IV : BASICS OF HEAT TRANSFER	(9)
Heat Transfer –Modes of heat transfer-Principles of conduction, convection and radiation – introduction to Various types of heat exchange equipments-cooler,condenser,chiller,exchanger-heater,reboiler-evaporator	
UNIT V :BASICS OF PROCESS CALCULATIONS	(9)
Basic concepts: Units and Dimensions, systems of units, conversion and conversion factors of units, concept of mole, weight percent, mole percent, simple problems.	
TOTAL (L:45)= 45 PERIODS	

TEXT BOOKS:

1. Dryden's Outlines of Chemical Technology for the 21st Century-GopalRao&Sittig-3rd Edition- Affiliated East West Press Pvt.Ltd, New Delhi.
2. Unit operations of chemical Engg.ByW.L.Mccabe and J.C .Smith-sixth edition-McGraw HillBook.co.Singapore-2001

REFERENCES:

1. Chemical Engineering Vol-1&II byJ.M.Coulson and J.F.Richordson-Sixth Edition Butterworth –New Delhi-2000
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 1997.
3. Unit Operations by G.G. brown-Wiley International Edition-1960

17CHMO2 BASIC PROCESS CALCULATIONS					
			L	T	P	C
			3	0	0	3
PREREQUISITE : NIL					

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To provide basic idea of basic chemical calculations.	1.1	Understand and apply composition of mixtures/solution and determine Pressure, volume and temperature of glass using equation of state	a,b,c,f,g
2.0	To gain fundamental knowledge and apply material balance without chemical reaction in process industry	2.1	Apply the law of conversion of mass for different batch and continues unit operations	a,b,c,d,f,g,k
3.0	To understand the material balance with chemical reaction in process industry	3.1	Apply the law of conversion of mass for unit processes and evaluate yield, conversion, recycle ratio/purge/bypass of chemical reactors	a,b,c,d,f,g,k
4.0	To Provide education and understand the apply energy balance in system	4.1	Apply energy balance for reacting system and understand the effect of temperature and pressure on heat of reaction	a,b,c,d,g,k
5.0	To learn the combined material and energy balances specific industries	5.1	Evaluate the combined material and energy balance of specific industries and understand industrial need for material and energy balance	a,b,c,d,f,g,k

UNIT I - BASIC CHEMICAL CALCULATIONS	**(9)**
Methods of expression; the ideal gas law; calculation of pressure, volume and temperature using ideal and Vander Waals equations. Use of partial pressure and pure component volume in gas mixture calculations; average molecular weight of gas mixture; density of gas mixture;	
UNIT II MATERIAL BALANCE WITHOUT CHEMICAL REACTION	**(9)**
Stoichiometric principles, application of material balance to unit operation like Distillation, Evaporation, Crystallization, Drying, Extraction, Mixing/Blending and Absorption. Humidification and dehumidification basic concepts -calculation of absolute molal, relative and percentage humilities; Use of psychometric chart;	
UNIT III – HEAT CAPACITY	**(9)**
Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible heat and latent heats, evaluation of enthalpy.	

UNIT IV – ENERGY BALANCE	(9)
Standard heat of reaction, heats of formation, combustion, solution, mixing etc., calculation of standard heat of reaction - Effect of pressure and temperature on heat of reaction. - Energy balance for systems with and without chemical reaction - Unsteady state energy balances	
UNIT V – COMBUSTION AND FLUE GAS ANALYSIS	(9)
Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gas fuels - Calculation of excess air from Orsat technique, problems on sulphur and sulphur burning compounds	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Bhatt B.L and Thakore S.B, “Stoichiometry”, 5th edition, Tata McGraw Hill publishing company, New Delhi, 2017.
2. Venkataramani V,Anantharaman N. and MeeraSheriffa Begum K.M, “Process Calculation “, 2nd edition, Prentice Hall of India , New Delhi ,2011.

REFERENCES:

1. Himmelblau D.M, “Basic Principle and calculation in Chemical Engineering”, 8thedition,Prentice Hall of India, New Delhi, 2013.
2. Richard M.Felder Ronald W .Rousseau, “Elementary Principles of Chemical Process”, 3rdedition, 2005.

17CHM03 HEAT TRANSFER OPERATIONS					
			L	T	P	C
			3	0	0	3
PREREQUISITE : NIL					
Course Objectives		Course Outcomes			Related Program outcomes
1.0	To understand nature and modes of heat transfer	1.1	Understand the fundamental principles of conduction		a, b, c, l
2.0	To gain explosive nature and forced convections and dimensional analysis	2.1	Acquire knowledge in convection and radiation heat transfer		a, b, c, l
3.0	To provide fundamentals of radiation concepts and nature of thermal radiations	3.1	Familiarize with the fundamentals of radiation and radiation shield		a, b, c, l
4.0	To have a basic idea of heat transfer with phase change and design evaporator	4.1	Apply the knowledge of heat transfer in the design of evaporators, boiling and condensation		a, b, c, f, k, l
5.0	To gain idea of different types of heat exchanger and performances	5.1	Design and analyze the performance of heat exchangers		a, b, c, f, k, l

UNIT I - CONDUCTION	(9)
Nature and modes of heat transfer; concept of heat conduction - Fourier's law, thermal conductivity of materials , one dimensional steady heat conduction –through plane wall, composite plane wall, cylinder, composite cylinder, sphere and composite sphere. Relationship between individuals and overall heat transfer coefficient; critical thickness of insulation;	
UNIT II – CONVECTION	(9)
Nature and forced convection - Application of dimensional analysis for convection dimensionless number, Reynolds and Colburn analogy, jH factor, Equation for forced convection under laminar and turbulent flow condition in pipes.	

UNIT III - RADIATION	(9)
Concepts and nature of thermal radiation, concepts of black and grey bodies; Stefan Boltzmann, Kirchhoff's, Plank's and Wien laws Radiation between surface configuration factor; radiation shield.	
UNIT IV EVAPORATORS	(9)
Introduction – Types of Evaporators (Standard vertical tube, long tube, Forced circulation)– Capacity – Steam economy – Boiling point elevation - Material and energy balance of single effect evaporator - surface area calculations for single effect evaporator - Theory of multiple effect evaporators.	
UNIT V HEAT EXCHANGERS	(9)
Types of heat exchangers; LMTD; use of correction factor charts, fouling factor, surface area calculation for double pipe and shell and tube heat exchangers; effectiveness and number of transfer units – Wilson's plot.	
TOTAL(L:45) = 45 PERIODS	
TEXT BOOKS: 1. YunusA.Cengel, "Heat Transfer: A practical approach ",2ndedition .McGrawhill,2002. 2. Dutta Binary K, "Heat Transfer Principle and application", Prentice Hall of India, New Delhi, 2000.	
REFERENCES: 1. J.P. Hollman,Souvik Bhattacharyya, "Heat Transfer " 10th Edition, McGrawhill,2011 2. Coulson J.M and Richardson J.F., "ChemicalEngineering Volume I", 6thedition, Elsevier publications, 2006.	

17CHM04 MASS TRANSFER OPERATIONS							
				L	T	P	C
				3	0	0	3
PREREQUISITE : NIL							
Course Objectives		Course Outcomes				Related Program outcomes	
1.0	To understand the basic concepts of diffusion and its measurement.	1.1	Understand diffusion operations in gases liquids and solids.			a, b, c, d, e, g, l	
2.0	To understand the mass transfer coefficients and their theories of mass transfer	2.1	Understand the concept of interphase mass transfer coefficients and equipment			a, b, c, d, e, g, l	
3.0	To gain knowledge over humidification and dehumidification and application in process industries.	3.1	Understand the concept humidifiers and cooling towers.			a, b, c, d, e, g, l	
4.0	To understand the mechanism of drying and types of drying equipment	4.1	Retrieve and apply the knowledge gained in mass transfer to perform simple calculations in drying			a, b, c, d, e, g, l	
5.0	To gain knowledge over crystallization and its application.	5.1	Apply the knowledge gained in mass transfer to perform simple calculations in crystallization process			a, b, c, d, e, g, l	

UNIT I : DIFFUSION	(9)
Diffusion in fluids - Molecular and eddy diffusion - Steady state diffusion under stagnant and laminar flow conditions -Diffusivity measurement and prediction-Diffusion in solids and its applications.	
UNIT II : DRYING	(9)
Theory and mechanism of drying, drying characteristics of materials, batch and continuous drying, Calculation of drying time under constant drying conditions, Different types of dryers and their applications.	
UNIT III : CRYSTALLIZATION	(9)
Principles of crystallization - methods of super saturation-law of crystal growth and growth coefficients, effect of tip speed. Calculations involving material and energy balances- Industrial crystallizers – Swenson, Oslo and their applications.	

UNIT IV : ABSORPTION	(9)
Choice of solvent, Co-current and counter-current operations, Tray tower absorber – Absorption factor – Calculation of number of theoretical stages, actual number of trays, Packed tower absorber – Tower packing and characteristics –Calculation of NTU, HTU and height of absorption towers.	
UNIT V : DISTILLATION	(9)
Vapour-liquid equilibria, Raoult's law and deviations from ideality. Principles of distillation: Simple distillation-calculations using Rayleigh equation, Flash vaporization, Continuous fractionation- Fenske equation, Number of ideal stages by Mc-Cabe - Thiele method for binary system.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. McCabe W.L., Smith J.C. and Harriot P., ―Unit Operations in Chemical Engineering‖, 7th Edition, McGraw-Hill International Edition, New York, 2006.
2. Treybal Robert E., ―Mass Transfer Operations‖, 3rd Edition, McGraw-Hill Book Company, 1980.

REFERENCES:

1. Anantharaman N. and MeeraSheriffa Begum K.M., ―Mass Transfer: Theory and Practice‖, Prentice Hall of India, New Delhi, 2011.
2. Welty J.R., Wilson R.E. and Wicks C.E., ―Fundamentals of Momentum Heat and Mass Transfer‖, 5th Edition, John Wiley, 2007.

17CHM05 FLUID MOVING MACHINERY					
				L	T	P	C
				3	0	0	3
PREREQUISITE : NIL							
Course Objectives		Course Outcomes		Related Program outcomes			
1.0	To understand the theory, construction and performance of Hydraulic machineries	1.1	Able to select and assesv the performance of different types of pumps	a, b, c, d, e			
2.0	To learn about power transmission and method of pump testing.	2.1	Familiarize with drives and power transmission of pumps and testing of pumps	a, b, c, d, e			
3.0	To understand the theory, construction and performance of compressors	3.1	Able to select and asses the performance of different types compressors	a, b, c, d, e			
4.0	To understand the types of flow measuring devices and to determine coefficient of discharge.	4.1	Familiarize with the types, theory and performance of blowers; Estimate the power requirement and efficiency of blowers	a, b, c, d, e			
5.0	To develop knowledge over theory, construction and performance analysis of fans.	5.1	Able to select and analyze the performance of different types of fans	a, b, c, d			

UNIT I HYDRAULIC MACHINERIES	(9)
Centrifugal pump- Theory, design, performance and construction. Displacement pump-Theory, design and construction. Diaphragm pump, screw pump –construction and working, performance, installation and diagnostics. Jet pump- theory and applications.	
UNIT II : POWER TRANSMISSION AND PUMP TESTING	(9)
Pump drives and power transmission-pump drives and speed varying devices. Pump sealing- Centrifugal pump packing, mechanical seal and injection type shaft seals .Pump noise measurement- Noise measurement techniques, estimating pump noise level and noise control techniques.	
UNIT III COMPRESSORS	(9)
Compressor Theory and types- Selection of compressors - Compressed air and air usage. Effect of operating conditions, Thermodynamic compression. Real gas effects. Description and control of surge in centrifugal and axial compressor.	

UNIT IV BLOWERS	(9)
Theory and types of Blowers- Selection of blowers- Working Principle of a Centrifugal Blower. Cross flow blowers –Flow pattern and performance. Vortex Blowers – Flow pattern and performance.	
UNIT V: FANS	(9)
Theory and types of Fans -Fan law- Conversion of fan performance, speed and size. Fan selection- Axial and centrifugal. Specific speed. Fan Performance and efficiency. Drives for Fans. Fanless air movers.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Giampaolo Tony "Compressor Handbook - Principles and Practices" Fairmount Press Incorporation, 2010
2. Igor J. Karassik, Joseph P. Messina, Paul Cooper, Charles C. Healdhe "Pump Handbook", 4th Edition, McGraw-Hill Company, New York, 2008.

REFERENCES:

1. Frank P. Bleier, "Fan Handbook – Selection, Application and Design", 2nd Edition, Mc-Graw Hill Companies Inc., 1997
2. Christie J. Geankoplis, "Transport Processes and Unit Operations", Prentice Hall of India, 1993

17CHM06 PROCESS PLANT UTILITIES					
			L	T	P	C
			3	0	0	3
PREREQUISITE : NIL					
Course Objectives		Course Outcomes			Related Program outcomes
1.0	To learn the importance of compressed air, Psychrometric and PSA systems	1.1	recognize the importance of compressed air, humidification and dehumidification process and PSA systems		a, c, d, g, l
2.0	To learn the requirement of water and steam i process industries	2.1	Comprehend the water treatment and steam utilization practices in process industries		a, c, d, g, l
3.0	To understand the vacuum systems for different chemical processes	3.1	Select suitable vacuum systems for different chemical processes		a, c, d, g, l
4.0	To study the principles of refrigeration process for application in chemical process industries	4.1	Grasp the principles of refrigeration process for application in chemical process industries		a, c, d, g, l
5.0	To know the importance of insulation and inert gases& To find the critical thickness of insulation; Gain an insight into the characteristics of	5.1	Understand the importance of insulation and calculate critical thickness of insulation; Gain an insight into the characteristics of inert gases.		a, c, d, g, l

UNIT I : HUMIDIFICATION	(9)
Air, Compressed air, Types and characteristics of fans, blowers and compressors. Air drying systems. Humidification and dehumidification of air. Production of oxygen and nitrogen by PSA systems.	
UNIT II : HEATING SYSTEM	(9)
Source and characteristics of water; soft water, hard water and Demineralised water. Treatment of water for boiler and cooling towers. Fuel and its Classification; Properties of steam; waste heat boilers. Thermic fluid System for process applications. Steam trap - classification, selection and applications. Efficient use of steam in process plants;	
UNIT III : VACUUM SYSTEM	(9)
Selection of vacuum systems; types and characteristics of vacuum pumps, steam jet ejectors and auxiliaries. Process equipment under vacuum – Separation columns, Reactors, Evaporators and Dryers.	

UNIT IV : REFRIGERATION	(9)
Principles, compression and absorption refrigeration systems. Types and properties of refrigerants, eco-friendly refrigerants.	
UNIT V : INSULATION AND INERT GAS	(9)
Importance of insulation. Insulation materials for high, intermediate, low and very low temperatures. Calculation of critical thickness of insulation. Properties of inert gases and their uses	
LECTURE(L:45)=45 PERIODS	

TEXT BOOKS:

1. Lyle O., "Efficient use of steam", HMSO Publishers, 2000
2. Jack Broughton, "Process Utility System- Introduction to Design Operation and Maintenance", Institution of Chemical Engineers, UK, 1994.

REFERENCES:

1. Mcquiston F.C and Parker J., "Heating, Ventilating & Air Conditioning – Analysis and Design", 3rd Edition, John Wiley, New York, 1988.
2. Eskel Nordell, "Water treatment for industrial and other uses", Reinhold Publishing Corporation, New York, 1961

17CHM07 PROCESS PLANT SAFETY					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					
Course Objectives		Course Outcomes			Related Program outcomes
1.0	To understand the importance of safety in industry	1.1	Demonstrate the awareness of plant safety, plant layout and the usage of safety codes.		a, e, f, l, j
2.0	To learn about the plant layout and plant maintenance	2.1	Understand the selection and replacement of process equipment		A, b, d, e, f
3.0	To learn about the plant hazards	3.1	Exhibit the skill in classifying chemical, fire, explosion hazards		A, b, e, f, g
4.0	To learn about risk analysis and assessment, hazard identification	4.1	Analyze the response to health hazards and to implement the effective process control		A, b, d, e, f, g
5.0	To learn about safe working rules and industrial act	5.1	Understand the rules and act framed by government for safe working environment		A, e, f

UNIT I– INTRODUCTION TO SAFETY	(9)
Need for safety in industries –Good layout of plant - Safety measures in storage and transportation of chemicals. Color code for pipelines, safety symbols and codes – spill control.	
UNIT II – PLANT MAINTENANCE	(9)
Plant maintenance, Personal protective equipment - Breathing and respiratory protection; Fire prevention – classification of fire – suppression – foam, dry chemical powder. Emergency planning.	
UNIT III – POTENTIAL HAZARDS	(9)
Potential hazards Hazard classification chemical, mechanical, noise hazards – Hazards due to ammonia, chlorine, sulphuric acid. Safety data sheet.	
UNIT IV HAZARD IDENTIFICATION AND CONTROL	(9)
HAZOP, Job safety analysis – Fault tree analysis – Event tree analysis – Failure modes and effect analysis Safety audit – Plant inspection –Past accident analysis–case study.	

UNIT V - LEGAL FRAMEWORK FOR SAFETY AND ENVIRONMENT	(9)
Rules – safe working environments – factories act – labour welfare act – ESI Act. Role of Government in safety organizations. OHSAS and ISO standards.	
TOTAL (L:45)= 45 PERIODS	

TEXT BOOK:

1. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004.
2. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ, 1990.
3. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987.
4. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965.

REFERENCES:

1. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., " Industrial Accident Prevention", McGraw- Hill Book Co., 1980
3. Handley, W., "Industrial Safety Hand Book ", 2nd Edn., McGraw-Hill Book Company, 1969.

17CHM08 ENGINEERING ECONOMICS AND MANAGEMENT					
			L	T	P	C
			3	0	0	3
PREREQUISITE : NIL					
Course Objectives		Course Outcomes		Related Program outcomes	
1.0	To understand basic of interest and capital cost	1.1	Able to understand value of money and depreciation with time	a, b, d, e, h	
2.0	To understand the feasibility of project and selection for investment	2.1	Able to select profitable project and calculate economic balance sheet	a, b, c, f, h, i	
3.0	To have a basic idea of economic balance	3.1	Can make economic balance on unit operations	c, d, e, g, h, k	
4.0	To understand the various concepts of economics and management	4.1	Able to understand the theory behind Inventory Control and organization Types	f, g, h, i, j, k	
5.0	To understand the principle of time study and production planning	5.1	Able to understand the theory behind the process development	f, h, i, j, k	

UNIT I TIME VALUE OF MONEY	(9)
Time value of money - equivalence, Supply and demand Depreciation, Depletion, estimation of capital cost, Capital requirement for complete plant, cost indices, capital recovery.	
UNIT II COST ESTIMATION	(9)
Estimation of project profitability, process optimization, Investment alternatives income statement, balance sheet preparation problems.	
UNIT III ECONOMIC BALANCE	(9)
Essentials of economic balance, economic balance in batch operations, cyclic operations, economic balance for insulation, evaporation, heat transfer equipments.	
UNIT IV PRINCIPLES OF MANAGEMENT	(9)
Principles of management, planning, organizing, staffing, coordinating, directing, controlling and communicating. Types of organizations.	

UNIT V PRODUCTION PLANNING AND CONTROL	(9)
Work measurement techniques, principles of time study, elements of production control, forecasting, planning, routing, scheduling, dispatching, inventory and control, role of control charts in production and quality control.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Peters and Timmerhaus, Plant design and Economics for Chemical Engineers, McGraw Hill 5th Edition, 2004.
2. Ahuja K.K, Industrial management, Khanna publishers, New Delhi, 1985.
3. Schweyer. H.E, “Process Engineering Economics”, Mc Graw Hill, 1969.
4. Engineering economics, R.Panneersevam, eastern economy edition.

REFERENCE

1. F.C. Jelen and J.H. Black, “Cost and Optimization Engineering”, McGraw Hill, 3rd Edn., 1992

22CHC01 – FUNDAMENTALS OF CHEMICAL ENGINEERING			
L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To understand the Fundamentals and basic concepts of Chemical Process Industries	1.1	Students will be able to apply the Concepts and Basics with suitable examples of Unit operations and Unit processes.
2.0	To gain an exposure on fluid behavior and its properties and types of fluids	2.1	Students will be able to explain the importance of fluid properties, types of fluids and select the manometers for pressure measurement. To predict the type of flow from Osborne Reynolds experiment.
3.0	To learn the fundamentals of Mechanical Operations and their significance in Solid handling Process industries	3.1	Students will be able to apply the principles of size reduction, separation and transportation of solids in chemical Industries.
4.0	To understand the basic concepts of Heat Transfer and Mass Transfer mechanisms and its Industrial equipment's	4.1	Students will be able to describe various modes of heat transfer and discuss about industrial equipment which falls on heat transfer with and without phase change and basic concepts and law in Mass transfer operation and discuss about gas – liquid contact equipment.
5.0	To have a basic idea on process calculations carried out in Chemical Process Industries.	5.1	Students will be able to apply the concepts of units and dimensions, basic chemical principles, weight percentage, mole percentage and material balances in process calculations.

UNIT I: BASICS OF CHEMICAL PROCESS INDUSTRIES	**(9)**
Unit process and Unit Operations concepts- Outlines of Unit process- Calcination, Carbonylation, Combustion, Hydration, dehydration, Hydrolysis, Nitration, Sulfonation, Polymerization – Addition and Condensation Polymerization.	
UNIT II: FUNDAMENTALS OF FLUID MECHANICS	**(9)**
Definition of fluids, Types of Fluids -compressible and incompressible fluids, Ideal and Real fluids. Physical properties of fluids-density, specific weight, specific volume, specific gravity, viscosity and vapor pressure. Pressure Measurement – Simple U-tube Manometer. Dimensionless Number– Reynolds number. Osborne Reynolds experiment – Laminar flow and Turbulent flow	
UNIT III: FUNDAMENTALS OF MECHANICAL OPERATIONS	**(9)**
Size reduction-Crushing and Grinding Equipment's and Uses, Solid - fluid Separations Equipment and Industrial uses, Gas-solid Separations Equipment and Industrial uses. Solid handling - Conveyors types and uses.	

UNIT IV: BASICS OF HEAT AND MASS TRANSFER	(9)
Heat Transfer –Modes of heat transfer-Principles of Conduction, Convection and Radiation. Definition of Boiling and Condensation. –Heat Transfer equipment's - Exchanger, Reboiler and Evaporator. Concept of Mass Transfer Operations - Diffusion, Humidification, Drying, Distillation, Absorption, Extraction, Leaching, Adsorption with examples.	
UNIT V: BASICS OF CHEMICAL PROCESS CALCULATIONS	**(9)**
Basic concepts: Units and Dimensions, systems of units, conversion and conversion factors of units, Basic chemical principles - Atomic weight , Molecular weight, Basis of calculation, concept of Mole, Mole fraction ,Mole percent, Weight percent, simple problems. Simple material balance calculations on drying, evaporation, distillation, absorption and Extraction	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Dryden's Outlines of Chemical Technology for the 21st Century – GopalRao & Sittig 3rd Edition- AffiliatedEast West Press Pvt.Ltd, New Delhi.
2. Venkataramani V,Anantharaman N. and Meera Sheriffa Begum K.M, Process Calculation ", 2nd edition, Prentice Hall of India , New Delhi ,2011.
3. McCabe, W.L., Smith, J. C. and Harriot, P. "Unit operations in Chemical Engineering", McGraw Hill, 7th Edition, 2001.

REFERENCES:

1. Salil K. Ghosal, Siddhartha Datta "Introduction to Chemical Engineering" Tata McGraw Hill Education.
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 6th Edition, Tata McGraw Hill, 1997.
3. Randolph Norris Shreve, George T. Austin, "Shreve'e Chemical Process Industries", 5th edition, McGraw Hill, 1984.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	1	-	-	1	-	-	-	-	-	-	-	-	3	2
2	2	1	1	1	-	-	-	-	-	-	-	-	3	2
3	-	1	1	1	-	-	-	-	-	-	-	-	3	3
4	-	2	1	1	-	-	-	-	-	-	-	-	3	2
5	2	1	1	-	-	-	-	-	-	-	-	-	3	2
CO (W.A)	1	1	1	1	-	-	-	-	-	-	-	-	**3**	**2**

*Ratified by Eleventh Academic Council

22CHC02 CHEMICAL ENGINEERING FLUID MECHANICS					
		L	T	P	C
		2	1	0	3
PREREQUISITE: 22CHC01					
Course Objectives		Course Outcomes			
1.0	To understand the basic concepts of fluid statics and dimensional analysis	1.1	Understand the concept of fluid statics and its applications; Apply the principles of dimensional analysis for engineering applications.		
2.0	To learn the fluid flow operations in pipes and basic equations associated with flow through pipes.	2.1	Analyze the types of fluid flow in pipes; Understand the basic equations in fluid flow operations.		
3.0	To gain knowledge over packed and fluidized beds used in process industries.	3.1	Retrieve and apply the concepts of flow around solids in packed and fluidized beds.		
4.0	To understand the types of flow measuring devices and to determine coefficient of discharge.	4.1	Appraise and select the flow measuring devices in process industries.		
5.0	To gain knowledge over classification of fluid moving machinery and their performance analysis.	5.1	Analyze the performance of fluid moving machinery and appraise the types of valves and pipe fittings in process industries.		

UNIT I - FLUID STATICS AND DIMENSIONAL ANALYSIS	**(6+3)**
Introduction to Fluid statics, properties and Based problems; Hydrostatic equation and its applications; Pressure measurement – Manometers and its types - Decanters; Units and Dimensions; Dimensional analysis – Models and Similitude – Types and principles of Similarity;	
UNIT II - FLOW THROUGH CONDUITS	**(6+3)**
Types of flow – Shear stress distribution - Laminar and turbulent flow in pipes; Friction factor - Moody Chart – Losses in piping system; Introduction to Boundary layer; Flow through non-circular conduits; Basic equations - Continuity equation - Bernoulli's equation and its applications;	
UNIT III - FLOW AROUND SOLIDS	**(6+3)**
Drag and its types - Drag coefficient; Industrial applications of Packed and fluidized bed - Packing materials; Pressure drop across packed bed - Ergun's equation; Fluidization and its classification - Pressure drop across the fluidized bed – Minimum fluidization velocity- Motion of particles through fluids – Terminal settling velocity;	
UNIT IV - FLOW METERING	**(6+3)**
Classification and Selection of flow meters; Principle, working and applications of Venturimeter, Orificemeter, rotameters and pitot tube; Determination of discharge coefficient; Other meters: Anemometer - Mass flow meter - High viscous flow meter; Notches and weirs;	

UNIT V	FLUID MOVING MACHINERY	(6+3)

Classification and selection of fluid moving machinery; Principle, working and applications of Centrifugal pump and Reciprocating pump - Characteristics curves of centrifugal pump; Elementary principles of gear, air lift, diaphragm and submersible pumps; Types and application of valves and pipe fittings;

TOTAL (L:30 + T:15) = 45 PERIODS

TEXT BOOKS:

1. Dr. R.K.Banzal ,"ATextbook of Fluid Mechanics and Hydraulic Machines , Nineth dition.2010. 2.McCabe W.L, Smith J.C. and Harriot P., "Unit Operations in Chemical Engineering", 7th Edition, McGraw Hill International Edition, New York, 2006.
2. Noel De Nevers,"Fluid Mechanics for Chemical Engineers", 3rd Edition, McGraw Hill, New York, 2004.

REFERENCES:

1. Cengel, Yunus and Cimbala John M, "Fluid Mechanics Fundamentals and Applications", 2nd Edition, Tata McGraw Hill Publishing Company, NewDelhi, 2006
2. J.M.Coulson and J.F.Richordson, "Chemical Engineering Vol - I & II", 6th Edition Butterworth – New Delhi-2000.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	2									2	
2	2	3	1	1		1							2	
3	2	3	3		2	1							2	
4	2	2	2	1									2	
5	1	2	3	2					1				2	
CO (W.A)	2	3	2	2	2	1			1				2	

22CHC03 - CHEMICAL PROCESS CALCULATIONS			
L	T	P	C
2	1	0	3

PREREQUISITE : 22CHC01

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To provide basic idea of basic chemical calculations.	1.1	Understand and apply composition of mixtures/solution and determine Pressure, volume and temperature of glass using equation of state
2.0	To gain fundamental knowledge and apply material balance without chemical reaction in process industry	2.1	Apply the law of conversion of mass for different batch and continues unit operations
3.0	To understand the material balance with chemical reaction in process industry	3.1	Apply the law of conversion of mass for unit processes and evaluate yield, conversion, recycle ratio/purge/bypass of chemical reactors
4.0	To Provide education and understand the apply energy balance in system	4.1	Apply energy balance for reacting system and understand the effect of temperature and pressure on heat of reaction
5.0	To learn the combined material and energy balances specific industries	5.1	Evaluate the combined material and energy balance of specific industries and understand industrial need for material and energy balance

UNIT I - BASIC CHEMICAL CALCULATIONS	**(6+3)**
Methods of expression; the ideal gas law; calculation of pressure, volume and temperature using ideal and Vander Waals equations. Use of partial pressure and pure component volume in gas mixture calculations; average molecular weight of gas mixture; density of gas mixture;	
UNIT II - MATERIAL BALANCE WITHOUT CHEMICAL REACTION	**(6+3)**
Stoichiometric principles, application of material balance to unit operation like Distillation, Evaporation, Crystallization, Drying, Extraction, Mixing/Blending and Absorption. Humidification and dehumidification basic concepts -calculation of absolute molal, relative and percentage humilities; Use of psychometric chart;	
UNIT III - MATERIAL BALANCE WITH CHEMICAL REACTION	**(6+3)**
Material balance for the systems involving chemical reaction; limiting and excess reactants- yield and selectivity. Bypass, recycle and purging.	

UNIT IV – ENERGY BALANCE	(6+3)
Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible heat and latent heats, evaluation of enthalpy. Standard heat of reaction, heats of formation, combustion, solution, mixing etc., calculation of standard heat of reaction - Effect of pressure and temperature on heat of reaction. - Energy balance for systems with and without chemical reaction - Unsteady state energy balances	
UNIT V – COMBUSTION AND FLUE GAS ANALYSIS	**(6+3)**
Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gas fuels - Calculation of excess air from Orsat technique, problems on sulphur and sulphur burning compounds	
TOTAL(L:30:T:15) = 45 PERIODS	

TEXT BOOKS:

1. Bhatt B.L and Thakore S.B, "Stoichiometry", 5th edition, Tata McGraw Hill publishing company, New Delhi, 2017.
2. Venkataramani V,Anantharaman N. and MeeraSheriffa Begum K.M, "Process Calculation ", 2nd edition, Prentice Hall of India , New Delhi ,2011.

REFERENCES:

1. Himmelblau D.M, "Basic Principle and calculation in Chemical Engineering", 8thedition,Prentice Hall of India, New Delhi, 2013.
2. Richard M.Felder Ronald W .Rousseau, "Elementary Principles of Chemical Process", 3rdedition, 2005.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1							1	2	1
2	3	3	3	2	1							1	2	1
3	3	3	3	3	1							1	2	1
4	3	3	2	3	2	2						2	2	2
5	3	3	3	3	1	2						2	1	1
CO (W.A)	3	3	3	3	1	2						1	2	1

22CHC04 UNIT PROCESSES FOR CHEMICAL ENGINEERS				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				
COURSE OBJECTIVES AND OUTCOMES:				

Course Objectives		Course Outcomes	
1.0	To learn the principle of Nitration and manufacture of amino compounds	1.1	Understand the various unit process in synthesis of organic compounds
	To develop knowledge about Halogenation, Sulfonation and Sulfation	4.1	Identify reaction schemes and mechanisms for a number of important reaction used in organic synthesis
3.0	To understand types of Oxidation, Ammonolysis,	3.1	Analysis of chemical reaction and reaction conditions of Oxidation, Ammonolysis.
5.0	To provide fundamental knowledge of Hydrogenation and Hydroformylation	5.1	Understand the synthesis of Hydrogenation and Hydroformylation.
	To have a basic ideas about production and properties of Hydrogenation and Alkylation	2.1	Understand the application of organic compounds in various industries

UNIT I Nitration and Amination	**(9)**
Principle of Nitration, nitrating agents and Nitration esters- Typical industrial equipment and processes- Nitration of Benzene and Propane; Principle of Amination methods – reduction and its methods, Manufacture of Aniline and Nitro-Aniline by different methods.	
UNIT II Halogenation and Sulfonation Processes	**(9)**
Halogenation reactions, Chlorination mechanism, Manufacture of Vinyl Chloride and Chloral. Sulfonation and sulfation agents, Industrial process- sulfonation of benzene and production of ethanol; Desulfonation reactions	
UNIT III : Ammonolysis and Oxidation	**(9)**
Principles of Ammonolysis. Aminating agents and amination reactions, Manufacture of Aniline, p-Pheneyldiamine and Methylamines; Principles of Oxidation, Oxidizing agents, Types of Oxidative reaction, Synthesis of Acetic acid, Formaldehyde and Styrene.	
UNIT IV : Hydrogenation and Hydroformylation	**(9)**
Production and Properties of Hydrogen, Catalytic hydrogenation and Hydrogenolysis - Hydrogenation of Cotton seed oil and Synthesis of Methanol; Methanation and Fisher-Tropsch reactions- Oxo, Synol processes.	

UNIT V : Esterification, Hydrolysis and Alkylation	(9)
Esterification of organic and inorganic acids, applications in chemical industries- Manufacture of ethyl acetate and vinyl acetate monomer; Hydrolyzing agents, processes and equipment-manufacture of Glycerol, Furfural and Ethanol. Types and Factors affecting alkylation, Industrial alkylation process-Alkyl aryl detergent	
TOTAL (L:45)= 45 PERIODS	

TEXT BOOK:

1. Austin G.T., "Shreve's Chemical Process Industries ",5th edition (Special Reprint edition),McGraw Hill International co., 2005.
2. Groggins P.H.,"Unit Processes in Organic Synthesis",5th edition (reprint),McGraw Hill International Co.,2001.

REFERENCES:

1. K.S.Tewari&N.K.Vishnoi, "A Textbook of Organic Chemistry" ,4rd Edition, Vikas Publishing House,New Delhi, 2017.
2. Graham Solomons T.W.,Craig B.Fryhle and scott A. Snyder,"Organic Chemistry",11th edition,international student version, John Wiley And sons inc, New York,2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	-	1	1	1	2	2	1	-	-	1	1	3	2
2	3	2	2	2	2	1	1	-	-	-	-	-	3	2
3	3	2	2	2	2	1	1	-	-	-	-	-	3	2
4	2	2	2	1	1	-	1	-	-	-	-	-	3	3
5	2	1	2	1	1	1	2	-	-	-	2	2	3	3
CO (W.A)	2	1	2	1	1	1	1	-	-	-	1	1	3	2

22CHC05 - MECHANICAL OPERATIONS				
	L	T	P	C
	3	0	0	3
PREREQUISITE : 22CHC01				
COURSE OBJECTIVES AND OUTCOMES:				

	Course Objectives		Course Outcomes
1.0	To understand how the solids are characterized and methods for storage and transportation of solids	1.1	The student will be able to demonstrate the knowledge of particle characterization, size analysis, storage and transportation of solids
2.0	To gain knowledge over size reduction equipments and industrial screens	2.1	The student will be able appraise and select the size reduction equipments and industrial screens
3.0	To obtain idea on the mechanical separation equipments in process industries	3.1	The student will be able understand and select the mechanical separation equipments based on surface properties of solids
4.0	To gain knowledge over filtration and types of industrial filters	4.1	The student will be able exhibit the principle of filtration and types of industrial filters
5.0	To understand and compare mixing and agitation process	5.1	The student will be able compare and recognize mixing and agitation equipments

UNIT I - CHARACTERISTICS AND HANDLING OF PARTICULATE SOLIDS	**9**
Characteristics of particulate solids, techniques for particle size analysis, agglomeration and segregation; different methods for storage and transportation of solids	
UNIT II - SIZE REDUCTION AND SCREENING	**9**
Laws of size reduction; classification, principle and working of size reduction equipments; screening-screen effectiveness- industrial screening equipments	
UNIT III - MECHANICAL SEPARATIONS	**9**
Principles and equipment for gravity settling, sedimentation, thickening, centrifugal separation, froth flotation, magnetic and electrostatic separators, heavy media separations	
UNIT IV - FILTRATION	**9**
Theory of filtration, constant pressure and constant rate filtration; batch and continuous filters; principle and equipment for gravity, pressure and centrifugal filters; selection of filters; vacuum filter and its application.	
UNIT V - MIXING AND AGITATION	**9**
Principles,typesandequipmentformixing;Impellers,powerrequirementforagitation; Mixer for powders and pastes, equipment for blending and kneading	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Coulson J.M.and Richardson J.F.,"Chemical Engineering", Volume II, 5thEdition, Elsevier publication,2006.
2. G.G. Brown "Unit Operations " 1stedition , CBSPublishers,2005

REFERENCES:

1. Badger WalterL.and BancheroJulius T,"Introduction to Chemical Engineering", Tata McGraw Hill Publishing Company,NewDelhi,21stReprint, 2008
2. Alans Foust, "Principles of Unit Operations", 2ndEdition,John Wiley &SonsInternational Edition, 2008.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	2	1	1	3	-	-	-	-	-	-	-	2	2	1
1	3	2	3	2	2	-	-	-	-	-	-	1	3	1
2	3	2	3	2	2	-	-	-	-	-	-	-	3	2
3	2	2	2	3	1	-	-	-	-	-	-	-	3	2
4	2	2	2	2	1	-	-	-	-	-	-	-	3	2
5	3	2	3	3	2	-	-	-	-	-	-	2	3	2
CO (W.A)	2	1	1	3	-	-	-	-	-	-	-	2	2	1

22CHP01 - FLUID MECHANICS LABORATORY

L	T	P	C
0	0	4	2

PRE REQUISITE : 22CHC02

	Course Objectives		Course Outcomes
1.0	To determine the coefficient of discharge of variable head and variable area flow meters	1.1	Determine the coefficient of discharge of venture meter, orifice meter, rotameter, open drum orifice and V notch.
2.0	To understand the relation between friction factor and Reynolds number for the flow through closed pipes.	2.1	Verify the Moody's chart for flow through straight pipe/concentric pipes and helical coil
3.0	To determine the energy loss for the flow through valves and pipe fittings	3.1	Predict the frictional loss coefficient for different valves and pipefittings
4.0	To study the pressure drop and superficial velocity for flow past immersed bodies.	4.1	Determine the pressure drop through packed bed and minimum fluidization velocity in fluidized bed
5.0	To test the performance of centrifugal and reciprocating pump	5.1	Draw the characteristics curves of centrifugal pump and reciprocating pump

LIST OF EXPERIMENTS

1. Determination of coefficient of discharge of venturimeter.
2. Determination of coefficient of discharge of orifice meter.
3. Determination of coefficient of discharge of notch.
4. Determination of friction factor for flow through straight pipe.
5. Determination of friction factor for flow through concentric pipes.
6. Determination of friction factor for flow through Spiral and helical coil.
7. Determination of pressure drop in packed bed.
8. Determination of minimum fluidization velocity flow through fluidized bed.
9. The study of characteristics curves of centrifugal pump.
10. The study of characteristics curves of reciprocating pump.

Total (60 P) = 60 periods

Reference

1. Lab Manual

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) /
Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	3	2	2									2	
2	1	1	1	1									1	
3	2	2	1	1									1	
4	2	2	2	2		1								
5	1	2	2	1		1							2	
CO (W.A)	2	2	2	1		1							2	

22CHP02 CHEMICAL ANALYSIS LABORATORY

L	T	P	C
0	0	4	2

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	Students will be able to prepare the various organic compounds at certain reaction conditions.	1.1	Make the student to acquire practical skills in the preparation of various organic compounds
2.0	To gain the knowledge in basic principle involved in analysis and identification of different organic compounds	2.1	Students will be able to learn the basic principle involved in analysis and identification of different organic compounds
3.0	To acquire knowledge and estimate the turbidity of water	3.1	Students will be able to gain the knowledge about turbidity and colour in water analysis
4.0	To provide hands on exposure for analyzing the given fuel oil sample	4.1	Students will be able to analyze the given fuel oil sample
5.0	To provide hands on exposure for performing cement analysis	5.1	Students will be able to understand the concept of cement analysis

LIST OF EXPERIMENTS (Any Ten)

1. Preparation of meta di nitro benzene from Nitro benzene.
2. Preparation of Benzoic acids from Ethyl benzoate.
3. Preparation of Benzoic acid from Benzaldehyde.
4. Determination of Turbidity and colour of waste water by using Nephlometer.
5. Determination of flash point, fire point, cloud and pour point of fuel oil.
6. Determination of aniline point of given fuel oil sample.
7. Determination of saponification value of oil.
8. Determination of purity of washing soda.
9. Identification of carbohydrates and/or acids from unknown organic compounds.
10. Identification of Phenol and/or ester from unknown organic compounds.
11. Identification of amine and/or Urea from unknown organic compounds.
12. Identification of Aldehyde and/or Ketone from unknown organic compounds.
13. Estimation of purity of Glycerol.

Total (60 P) = 60 periods

Reference:
1.Lab Manual

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) /
Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	2	1	1									1	-
2	1	2	3	1									-	1
3	2	1	3	1	1	1							-	-
4	1	2	3	1	1	2							1	-
5	2	1	3	1	1	2							-	-
CO (W.A)	1	2	3	1	1	1							1	1

22CHC06- CHEMICAL REACTION ENGINEERING					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		Course Outcomes			
1.0	To understand the basic concepts of chemical kinetics studies and types of reactions.	1.1	The students will be able to understand the concept of stoichiometric equations, order of reaction and chemical kinetic theories.		
2.0	To learn the mass and energy balance of ideal reactors of batch and continues operations.	2.1	The students will be able to understand the performance equations of ideal reactors.		
3.0	To gain knowledge over multiple rectors with series/parallel configurations.	3.1	The students will be able to apply knowledge of performance studies to compare reactors of different types in series and parallel.		
4.0	To understand the types of multiple reactions.	4.1	The students will be able to learn the concepts of multiple reactions involved in PFR and MFR.		
5.0	To gain knowledge of non-isothermal and adiabatic reactor performance.	5.1	The students will be able to analyze the performance of reactors under steady state non-isothermal conditions.		

UNIT I FUNDAMENTAL CONCEPTS AND CHEMICAL KINETICS	**(9)**
Chemical Kinetics, Classification of chemical reactions, Rate, rate equation, rate constant, Order and Molecularity, activation energy, Arrhenius theory, collision theory ,transition state theory, Elementary and non-elementary reactions, half-life period, constant volume reaction- Irreversible unimolecular type first order reactions. Variable volume Batch reactor. Zero order reaction.	
UNIT II : DESIGN OF SINGLE IDEAL REACTORS	**(9)**
Chemical reactors: Batch reactors, performance equation. Advantages and disadvantages of Batch reactors, Space time and space velocity. Simple calculations. CSTR, performance equation, Conversion yield, Simple problems.	
UNIT III : DESIGN OF MULTIPLE REACTORS	**(9)**
Steady state Mixed flow reactors performance equation, Plug flow reactor Design equation, Mixed flow reactors in series and parallel connection, Plug flow reactors in series and parallel connection, reactors of different types in series. Simple problems	
UNIT IV : DESIGN FOR MULTIPLE REACTIONS	**(9)**
Series reactions, parallel reactions, series-parallel reactions, qualitative discussion about product distribution in mixed flow reactor, quantitative treatment of product distribution in mixed flow reactor, overall fractional yield ,instantaneous fractional yield, selectivity.Simple problems.	
UNIT V :BASIC CONCEPTS OF NON-IDEAL FLOW	**(9)**
Residence time distribution, RTD Measurement, Characteristics of a tracer, E curve, C curve and F curve, Mean residence time, The RTD in a plug flow reactor, State of aggregation of the flowing stream, Simple problems.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:
1. H.S. Fogler, Elements of Chemical Reaction Engineering, 3rd Ed., Prentice Hall India Pvt. Ltd., New Delhi,2001 2. O. Levenspiel, Chemical Reaction Engineering, 3rd Ed., Wiley Publications, 1999.
REFERENCES:
1. Gilbert F Froment, Kenneth B Bischoff and Juray D Wilde "Chemical Reactor Analysis and Design", Wiley, New York (2010). 2. J.M. Smith, Chemical Engineering Kinetics, 2nd Ed., McGraw-Hill, 1981. 3. P.V. Danckwerts, Gas-liquid reactions, Sharma and Doraiswamy Vols. I & II Froment and Bischoff.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	2	2	1									1	-
2	1	3		1									2	2
3	1	3		2	2								-	-
4	1	3		1	2								-	2
5	1	2		1	2								-	2
CO (W.A)	1	3	2	1	2								1	2

22CHC07 PROCESS HEAT TRANSFER					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : 22CHC01					
Course Objectives		Course Outcomes			
1.0	To understand nature and modes of heat transfer	1.1	Students will be able to familiarize with the fundamental concepts of Heat Transfer. Provide the student with knowledge about heat transfer by conduction in solids for steady state		
2.0	To gain explosive nature and forced convections and dimensional analysis	2.1	Apply convective heat transfer and use of heat transfer coefficients for laminar and turbulent flows conditions.		
3.0	To provide fundamentals of convection with phase change and thermal radiation concepts.	3.1	The course provides the student with knowledge about heat transfer with phase change (boiling and condensation) and thermal radiation.		
4.0	To gain idea of different types of heat exchanger and performances	4.1	Students will be able to calculate and use overall heat transfer coefficients in designing heat exchangers		
5.0	To have a basic idea of heat transfer with phase change and design evaporator	5.1	Students will be able to estimate the heat transfer rate and surface area of evaporators.		

UNIT I: CONDUCTION	**(9)**
Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer – Concept o thermal conductivity measurement-effect of temperature on thermal conductivity - Fourier's Law - One dimensional steady state heat conduction through plane and composite walls, hollow cylinder and composite cylinder - critical thickness of insulation; fundamental concepts in extended surfaces heat transfer; Transient heat conduction.	
UNIT II : CONVECTION (without phase change)	**(9)**
Concepts of heat transfer by convection - Natural and forced convection - Application of dimensional analysis for convection and dimensionless numbers - Relationship between Individual and overall heat transfer coefficients - Equations for natural convection in vertical plates and vertical and horizontal cylinders - Equations for forced convection under laminar and turbulent flow conditions in pipes.	
UNIT III: CONVECTION (with phase change) AND RADIATION	**(9)**
Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation - Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling - condensers-vertical and horizontal types. Concept and nature of thermal radiations -Concept of Black and grey bodies; Stefan Boltzmann, Kirchhoff,,s, Planck,,s and Wien laws- Radiation shield.	
UNIT IV HEAT EXCHANGERS	**(9)**
Heat Exchangers – Classification- Types and practical application (Double Pipe and Shell and Tube heat exchanger) – LMTD - use of correction factor charts - Fouling factors - surface area calculations for double pipe and shell and tube heat exchangers - NTU and efficiency of Heat exchangers.	

UNIT V EVAPORATORS	(9)
Introduction – Types of Evaporators (Standard vertical tube, long tube, Forced circulation)– Capacity – Steam economy – Boiling point elevation - Material and energy balance of single effect evaporator - surface area calculations for single effect evaporator - Theory of multiple effect evaporators.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Holman, J. P., 'Heat Transfer ', 10th Edn., McGraw Hill,2010.
2. Ozisik, M. N., Heat Transfer: A Basic Approach, McGraw-Hill, 1984
3. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.
4. B.K. Dutta, Heat transfer principles and applications, PHI Learning PVT Ltd, 2016

REFERENCES:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering",6th Edn., McGraw-Hill, 2001.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering " Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2									2	3	2
2	3	3	2									2	3	2
3	3	3	2									2	3	2
4	3	3	3		1							2	3	3
5	3	3	3		1							2	3	3
CO (W.A)	3	3	2		1							2	3	2

22CHC08 - CHEMICAL ENGINEERING THERMODYNAMICS					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		Course Outcomes			
1.0	To Have a basic concepts and laws of thermodynamics	1.1	The students will be able to apply thermodynamic concepts and the laws of thermodynamics to various systems and processes		
2.0	To learn the fundamental properties of Real gases and thermodynamics formulation	2.1	The students will be able to evaluate the PVT behavior of ideal and real gases		
3.0	To gain exposure to properties of solution	3.1	The students will be able to understand the properties of solution and determine the partial molar properties from mixture properties and vice- versa		
4.0	To understand the Phase equilibrium between phase and engineering systems	4.1	The students will be able to apply chemical reaction equilibrium between phase to engineering system with two or more coexisting phases		
5.0	To develop knowledge on chemical reaction equilibrium for homogenous reactions	5.1	The students will be able to understand chemical reaction equilibrium for thermodynamic analysis of homogeneous reaction		

UNIT I LAW OF THERMODYNAMICS	**(9)**
Basic concepts; Terminology of Thermodynamics, Zeroth law; First law; application to non-flow and flow processes; second law –heat engine, Carnot cycle and theorem, Entropy calculation; Third law of thermodynamics.	
UNIT II: PROPERTIES OF REAL GASES AND THRMODYNAMICS FORMULATIONS	**(9)**
Ideal Gas law - simple problems PVT behavior of fluids – compressibility factor; two and three parameter theorems of corresponding states. Equation of state – Virial, Vander Waals, Redlich-Kwong and Peng-Robinson equation; Basic energy relations; Maxwell relations and Pnemonic diagram.	
UNIT III: PROPERTIES OF SOLUTIONS	**(9)**
Partial molar properties Chemical potential, Fugacity, Activity and Activity coefficient; Gibbs-Duhem equation, Applications Raoult's law and Henry's law simple problems, enthalpy and Gibbs free energy change in mixing of ideal solution	
UNIT IV -PHASE EQUALIBRIA	**(9)**
Phase equilibrium and stability criteria for equilibrium between phases in single and multi-component non-reacting system; vapor –liquid equilibrium of binary solution (ideal and non ideal) ; Azeotropes P-x-y and T-x-y diagrams.	

UNIT V - CHEMICAL EQUILIBRIA	(9)
Criteria of equilibrium; standard free energy change and reaction equilibrium constant Kp and Kc; effect of temperature and pressure on reaction equilibrium constant Relationship between Kp and Kc. Simple problems.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Narayanan K.V., "A Text book of Chemical Engineering Thermodynamics", 2ndedition,Prentice Hall India Pvt. ltd., New Delhi,2013
2. SmithJ.M., Van Ness H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics", 7thedition,McGraw Hill,2009.

REFERENCES:

1. Rao Y.V.C., "Chemical Engineering Thermodynamics", Universities press (India) Ltd., Hyderabad (A.P), India,2004.
2. KyleB.G.,"Chemical and Process Thermodynamics",3rdEdition,Prentice Hall India Pvt. ltd., New Delhi,1999

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1	2	1									1	-
2	1	2	3	2									-	2
3	1	2	3	1	1	2							-	1
4	1	3	2	1	1	1							1	-
5	1	2	3	1	2								2	-
CO (W.A)	1	2	3	1	1	1							1	1

22CHC09 - MASS TRANSFER I					
			L	T	P	C
			3	0	0	3
PREREQUISITE : 22CHC01					
COURSE OBJECTIVES AND OUTCOMES					
Course Objectives		Course Outcomes			
1.0	To understand the basic concepts of types of diffusion in mass transfer.	1.1	Able to calculate mass transfer flux and know the methods of diffusivity measurement.		
2.0	To understand the mass transfer theories and inter-phase mass transfer.	2.1	Understand the theories of mass transfer and can calculate mass transfer coefficient.		
3.0	To gain knowledge over cooling tower and its operations.	3.1	Able to calculate humidification operations in cooling tower and applications of humidity chart.		
4.0	To understand the mechanism of drying and types of dryers	4.1	Understand the concept drying rate and able to find drying time in various drying operations.		
5.0	To gain knowledge over crystallization and its application.	5.1	Understand the concept of crystallization process and identification of suitable crystallizer		

UNIT I DIFFUSION	**(9)**
Introduction to mass transfer operations - Molecular and eddy diffusion in gases and liquids – Steady state molecular diffusion in fluids at rest and in laminar flow - Binary diffusivity measurement and prediction - Multi component diffusion and diffusion in solids.	
UNIT II : INTERPHASE MASS TRANSFER	**(9)**
Concept of mass transfer co-efficient, Theories of mass transfer - film, penetration and surface renewal theories, momentum, heat and mass transfer analogies. Inter phase mass transfer – relationship between individual and overall mass transfer coefficient – Equipment for gas-liquid operations – Sparged and agitated vessels, Sieve and tray tower, Venturi scrubber and packed tower.	
UNIT III : HUMIDIFICATION	**(9)**
Humidification –Terminology and definitions - Equilibrium, humidity chart, adiabatic saturation and wet bulb temperatures - Cooling tower construction and its operation, calculations - Adiabatic humidification and dehumidification operations.	
UNIT IV : DRYING	**(9)**
Drying - Terms and definitions – Equilibria, the drying rate curve - Batch Drying – material and energy balance - Theoretical estimation of drying time from rate data - determination of length of rotary dryer using rate concept - Mechanism and time of cross through circulation drying. Classification of dryers - Advance drying techniques such as freeze drying, microwave drying;	

UNIT V : CRYSTALLIZATION	(9)
Principle of crystallization - Equilibrium, theory of super saturation, nucleation and crystal growth, Batch and continuous operation - mass and energy balance - yield and purity of products; classification of crystallizers and crystallisation equipment.	
TOTAL(L:45 T:15) = 60 PERIODS	

TEXT BOOKS:

1. Treybal, R. E., "Mass Transfer Operations", 3rd Edition, McGraw-Hill,2017.
2. Geankoplis, C.J., "Transport Processes and Unit Operations", 4 th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Narayanan K.V. and Lakshmikutty, B "Mass Transfer – Theory and Applications", 1 st Edition, CBS Publishers & Distributors Pvt Ltd, New Delhi, 2014.

REFERENCES:

1. Anantharaman N. and MeeraSheriffa Begum K.M., —Mass Transfer: Theory and Practice‖ , Prentice Hall of India, New Delhi, 2011.
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7 thEdition., McGraw-Hill, 2005.
3. Seader J.D. and Henley E.J., "Separation Process Principles", 4th Ed., John Wiley, 2016
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, 5th Edition, Asian Books Pvt. Ltd., India, 2002.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
CO No	POs												PSOs	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	3	3	3	1	1	-	1	-	-	-	-	3	3	1
2	3	3	3	1	1	-	1	-	-	-	-	3	3	1
3	3	3	3	1	1	-	1	-	-	-	-	3	3	1
4	3	3	3	1	1	-	1	-	-	-	-	3	3	1
5	3	3	3	1	1	-	1	-	-	-	-	3	3	1
CO (W.A)	3	3	3	3	1	0	1					3	3	1

22CHC10 - INSTRUMENTAL METHODS OF ANALYSIS					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		Course Outcomes			
1.0	To understand the concept of instrumental method of analysis	1.1	Gain the knowledge about analysis method and the traditional method of analysis		
2.0	To learn basic idea, Principles and applications of various spectroscopic methods	2.1	Known the principles of UV -Visible spectroscopy, IR spectroscopy and other modern instrumental method of analysis		
3.0	To explore a knowledge in thermal analysis and morphology analysis	3.1	Understand the concept and theory behind in thermal analysis and morphology analysis		
4.0	To have a basis knowledge and principles in conductance and electrophoresis techniques	4.1	Gain the knowledge about working principles and application of conductance, potential measurements and electrophoresis		
5.0	To learn the principles, working and applications of various chromatography methods	5.1	Examine the concept, working principle and applications of various chromatography methods		

UNIT I: INTRODUCTION OF INSTRUMENTAL METHODS	**(9)**
Introduction-Methods of detecting analytes-Qualitative and Quantitative Analysis-Volumetric analysis-Gravimetry-Traditional analytical techniques - Spectroscopy, Crystallography, Electrochemical analysis and separation techniques	
UNIT II: MOLECULAR SPECTROSCOPY	**(9)**
Modern instrumental Methods of analysis - Principles and applications of UV-Visible Spectroscopy, IR Spectroscopy and Non –dispersive IR, Raman spectroscopy, NMR Spectroscopy, Atomic absorption spectroscopy, X-ray fluorescence and ION Chromatography	
UNIT III: THERMAL METHODS AND MORPHOLOGY ANALYSIS	**(9)**
Thermogravimetry Principle, instrumentation and applications, factors affecting shapes of thermograms. Differential Thermal Analysis: Principle, instrumentation and applications. Differences between DSC and DTA. Application of DSC (Inorganic & Polymer samples). Morphology Analysis – Scanning Electron Microscopy – Transmission Electron Microscopy – Principle and Applications	
UNIT IV: CONDUCTANCE, POTENTIAL MEASUREMENT AND ELECTROPHORESIS	**(9)**
Definitions, conductance measurements, applications, Types, advantages and disadvantages of Conductometric titrations. Potential measurements, pH determination, Potentiometric Titrations. Basic principles of electrophoresis, theory and application of paper, starch gel, agarose, PAGE, SDS-PAGE electrophoresis.	

UNIT V: CHROMATOGRAPHIC METHODS	(9)
Introduction – Classification of chromatographic methods: Column chromatography, Thin Layer chromatography, Paper chromatography, Gas chromatography and High-Performance Liquid Chromatography (HPLC) – Principle, important components and their functions mode of separation, Instrumentation and applications	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Gurdeep R. Chatwal Shan K Anand, "Instrumental methods of Chemical Analysis", 5th Edition, Himalaya Publishing House, New Delhi, 2018
2. Muralidharan Rao.D , Swamy A.V.N , Dharaneeswaran Reddy D, "Instrumental Method of Analysis", CBS Publishers and Distributors, 2013.

REFERENCES:

1. Willard H.H., Merritt L.L., Dean J.A., and Settle F.A., "Instrumental Methods of Analysis", 7th Edition, C B S Publishers & Distributors, Delhi, 2004.
2. Daniel C. Harris, "Qualitative chemical analysis", 9th Edition, W. H. Freeman and Company, New York, 2015
3. Skoog D.A and West D.M "Fundamental of Analytical Chemistry", 7 th edition, Saunders college publishing, New York,1996.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	1	2	-		-	-	-	-	-	-	3	2
2	2	2	2	2	1	1	-	-	-	-	-	-	3	2
3	2	2	1	1	2	1	-	-	-	-	-	-	3	3
4	2	2	1	1	1	1	-	-	-	-	-	-	3	2
5	2	2	2	2	1	1	-	-	-	-	-	-	3	2
CO (W.A)	2	2	1	2	1	1	-	-	-	-	-	-	3	2

22CHC11 - CHEMICAL PROCESS INDUSTRIES

L	T	P	C
3	0	0	3

PREREQUISITE : 22CHC01

Course Objectives		Course Outcomes	
1.0	To understand the properties and production of fuels and Industrial gases	1.1	The student will be able to understand the nature, properties and method of production of fuels and Industrial gases.
2.0	To gain the knowledge about the cement industries and the production of various acids	2.1	The student can gain knowledge about the cement industries and the production of various acids
3.0	To gain knowledge over the pulp, paper, sugar and starch industries	3.1	The student can gain knowledge over the pulp, paper, sugar and starch industries and its importance
4.0	To gain knowledge about the fertilizers and its production methods.	4.1	The student will be able to understand the method of production of various fertilizers and its uses.
5.0	To understand the concept of different polymers and its production methods.	5.1	The student will be able to understand production of different types polymers

UNIT I: FUEL AND INDUSTRIAL GASES	**(9)**
Fuel Gases – Natural gas, Liquefied natural gas, Synthesis Gas. Industrial gases – Carbon dioxide, hydrogen, nitrogen and oxygen – Argon.	
UNIT II: ACIDS AND CEMENT INDUSTRY	**(9)**
Sulfuric acid, Nitric acid and Phosphoric acid. Cement – properties of Cement – Methods of production – Overall factors for Cement industry.	
UNIT III: PULP, PAPER, SUGAR AND STARCH INDUSTRIES	**(9)**
Pulp – Methods of production – Comparison of pulping processes. Paper – types of paper products, Raw materials, Methods of production. Sugar – Methods of production – by products of the Sugar industry – Starch – Methods of production, Starch derivations.	
UNIT IV: FERTILIZER INDUSTRY	**(9)**
Major Components of Fertilizer industries – Nitrogen industries, ammonia, urea – Phosphorus industries, Single Super Phosphate, DAP, MAP and NPK – Potassium chloride, Potassium Sulphate – Liquid Fertilizers – Bio Fertilizers.	
UNIT V: POLYMERS	**(9)**
Polymers production: Fibers, Rubbers and Plastics. Acrylonitrile butadiene styrene (ABS), polyethylene - LDPE, HDPE, Polypropylene, PVC, PS, SAN, SBR, PAN, Nylon and Polycarbonates.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Austin G.T., —Shreve's Chemical Process Industries‖ , 5th Edition, McGraw-Hill International Book Company, Singapore, 2012.
2. GopalaRao M. and Marshall Sittig, — Dryden‘s Outlines of Chemical Technology‖ , 3rd Edition, East- West Press, New Delhi, 2008.

REFERENCES:

1. Mark W.V. and Bhatia S.C., —Chemical Process Industries‖ , Volume - I and II, 2nd Edition, CBS Publishers and Distributors, New Delhi, 2007
2. Kent J.A., —Riggel's Hand Book of Industrial Chemistry‖ , Van Nostrant Reinhold, 1974

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	3	2	1	2	2	2					2	1
2	3	2	2	2	1	2	2	2					2	1
3	2	2	2	1	1	1	1						2	1
4	3	3	3	2	2	2	2	2					2	2
5	2	2	2	2	1	1	1	1					1	1
CO (W.A)	3	3	3	2	1	2	2	2					2	1

22CHP03 PROCESS HEAT TRANSFER LABORATORY			
L	T	P	C
0	0	4	2

PREREQUISITE: 22CHC07

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To determine individual and overall heat transfer coefficient using packed column and thermal conductivity of a material	1.1	Determine heat transfer coefficient for packed column apparatus and determine the thermal conductivity of given material
2.0	To estimate individual heat transfer coefficient under forced convection	2.1	Evaluate the performance and determine individual and overall HTC
3.0	To study the radiation heat transfer and calculate Stefan-Boltzmann constant.	3.1	Able to understand radiation heat transfer
4.0	To estimate the HTC for heat transfer through heat exchangers.	4.1	Estimate the HTC for heat transfer through double pipe heat exchangers and shell and tube heat exchangers.
5.0	To estimate steam economy and efficiency of an evaporator	5.1	Appraise the performance of evaporator and determine steam economy

LIST OF EXPERIMENTS
MECHANICAL OPERATIONS LABORATORY (Any Ten)

1. Estimation of individual and overall heat transfer coefficient for heat transfer in Packed Column
2. Estimation of unsteady state temperature values using transient heat conduction experiment constant flux and constant temperature.
4. Estimation of individual heat transfer coefficient under forced convection heat transfer.
5. Estimation of individual heat transfer coefficient under natural convection heat transfer.
6. Estimation of individual and overall heat transfer coefficient for heat transfer in shell and tube heat exchanger
7. Estimation of individual and overall heat transfer coefficient for heat transfer in double pipe heat exchanger
8. Estimation of individual heat transfer coefficient and fin efficiency for heat transfer through extended surface
9. Estimation of steam economy and efficiency of an evaporator
10. Heat transfer studies in pool boiling
11. Estimation of individual heat transfer coefficient for heat transfer through horizontal and vertical condenser
12. Estimation of individual and overall heat transfer coefficient for heat transfer in jacketed vessel

13. Estimation of thermal conductivity of a material. 14. Studies on radiation heat transfer 15. Determination of Stefan Boltzmann constant using Stefan Boltzmann experiment
TOTAL(P:60) = 60 Periods
References: 1. Laboratory manual

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	1	2			1			1		1	2	2
2	3	3	1	2			1			1		1	2	2
3	3	3	1	2			1			1		1	2	2
4	3	3	1	2			1			1		1	2	2
5	3	3	1	2			1					1	2	2
CO (W.A)	3	3	1	2			1			1		1	2	2

22CHP04 - MECHANICAL OPERATIONS LABORATORY				
	L	T	P	C
	0	0	4	2
PREREQUISITE: 22CHC05				
COURSE OBJECTIVES AND OUTCOMES:				

Course Objectives		Course Outcomes	
1.0	To determine power requirements and crushing laws constants using Jaw crusher and Roll crusher	1.1	The student will be able to assess power requirements and crushing laws constant using Jaw crusher and Roll crusher.
2.0	To predict the critical speed and work index by using Ball mill and particle size analysis by conducting Sieve Analysis	2.1	The student will be able to determine the critical speed and assess work index by using Ball mill and particle size analysis by conducting Sieve Analysis
3.0	To determine specific cake and filter medium resistance using Filter press, Leaf filter and Rotary drum filters.	3.1	The student will be able to determine specific cake and filter medium resistance using Filter press, Leaf filter and Rotary drum filters.
4.0	To design a thickener by conducting batch sedimentation test and to determine the separation efficiency of cyclone separator.	4.1	The student will be able to design a thickener using batch sedimentation test data and assess the separation efficiency of cyclone separator.
5.0	To find the separation efficiency of froth flotation equipment.	5.1	The student will be able to find the separation efficiency of froth flotation equipment.

LIST OF EXPERIMENTS

MECHANICAL OPERATIONS LABORATORY (Any Ten)

1. Determination of the crushing law constants using Jaw crusher
2. Determination of the Reduction ratio using crushing rolls
3. Determination of the critical speed of ball mill
4. Determination of the average particle size using size analysis and finding the effectiveness of Screen
5. Determination of the specific cake resistance and filter medium resistance using plate and frame filter press
6. Determination of the specific cake resistance and filter medium resistance using vacuum leaf filter.
7. Determination of the specific cake resistance and filter medium resistance using vacuum rotary drum filter

8. Determination of minimum thickener area by batch sedimentation test
9. Determination of the separation efficiency of cyclone separator.
10. Determination of separation efficiency of froth flotation equipments.
11. Determination of the specific surface area of the given powder using air permeability apparatus
12. Determination of Power Consumption & Power Number by using Mixing apparatus.

TOTAL(P:60) = 60 Periods

REFERENCES:

1. Laboratory manual:

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs														
COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2	2	-	-	-	-	-	-	-	-	2	1
2	2	2	3	2	-	-	-	-	-	-	-	-	2	2
3	2	3	2	2	2	-	-	-	-	-	-	-	3	1
4	2	1	2	1	1	-	-	-	-	-	-	-	2	1
5	2	1	2	1	1	-	-	-	-	-	-	-	2	1
CO (W.A)	2	2	2	2	1	-	-	-	-	-	-	-	2	1