RV COLLEGE OF ENGINEERING

(Autonomous Institution Affiliated to VTU, Belagavi)

R.V.Vidyaniketan Post, Mysore Road

Bengaluru – 560 059

Scheme and Syllabus of I & II Semesters

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)

in

CHEMICAL ENGINEERING

DEPARTMENT OF

CHEMICAL ENGINEERING

INNER FRONT COVER PAGE

College Vision & Mission
(To be included from our side)

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ABBREVIATIONS

Sl. No.	Abbreviation	Meaning
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	CE	Professional Core Elective
6.	GE	Global Elective
7.	HSS	Humanities and Social Sciences
8.	CV	Civil Engineering
9.	ME	Mechanical Engineering
10.	EE	Electrical & Electronics Engineering
11.	EC	Electronics & Communication Engineering
12.	IM	Industrial Engineering & Management
13.	EI	Electronics & Instrumentation Engineering
14.	CH	Chemical Engineering
15.	CS	Computer Science & Engineering
16.	TE	Telecommunication Engineering
17.	IS	Information Science & Engineering
18.	BT	Biotechnology
19.	AS	Aerospace Engineering
20.	PHY	Physics
21.	CHY	Chemistry
22.	MAT	Mathematics

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RV COLLEGE OF ENGINEERNG, BENGALURU-560 059
(Autonomous Institution Affiliated to VTU, Belagavi)
DEPARTMENT OF CHEMICAL ENGINEERING
M.Tech in CHEMICAL ENGINEERING

FIRST SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Total Credits**
1	18MAT 11A	Applied Mathematics	Maths	4	0	0	**4**
2	18MCH 12	Modelling and Simulation of Processes	CH	4	0	1	**5**
3	18MCH 13	Process Equipment Design	CH	4	0	1	**5**
4	18HSS 14	Professional Skills Development	HSS	0	0	0	**0**
5	18MCH 1AX	Elective - A	CH	4	0	0	**4**
6	18MCH 1BX	Elective - B	CH	4	0	0	**4**
Total number of Credits				**20**	**0**	**2**	**22**
Total Number of Hours / Week				**20**		**4**	

SECOND SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Total Credits**
1	18MCH 21	Plant Wide Control of Chemical Process	CH	4	0	1	**5**
2	18MCH 22	Heterogeneous Reaction Systems	CH	4	0	0	**4**
3	18IEM 23	Research Methodology	IM	3	0	0	**3**
4	18MCH 24	Minor project	CH	0	0	2	**2**
5	18MCH 2CX	Elective -C	CH	4	0	0	**4**
6	18MCH 2DX	Elective -D	CH	4	0	0	**4**
7	18XX2G XX	Elective –G (Global Elective)	Respective boards	3	0	0	**3**
Total number of Credits				**22**	**0**	**3**	**25**
Total Number of Hours / Week				**22**		**6**	

I Semester		
GROUP A: CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	18MCH 1A1	Solid Waste Management
2.	18MCH 1A2	Fuel Cell Technology
3.	18MCH 1A3	Piping Engineering
GROUP B: CORE ELECTIVES		
1.	18MCH 1B1	Renewable Energy Resources and Systems
2.	18MCH 1B2	Industrial Waste Water Treatment
3.	18MCH 1B3	Interfacial Phenomena and Surface Engineering
II Semester		
GROUP C: CORE ELECTIVES		
1.	18MCH 2C1	Fluidization Engineering
2.	18MCH 2C2	Oil and Gas Processing
3.	18MCH 2C3	Biochemical Engineering
GROUP D: CORE ELECTIVES		
1.	18MCH 2D1	Advanced Polymer Composites
2.	18MCH 2D2	Chemical Process Integration
3.	18MCH 2D3	Nanotechnology in Chemical Engineering

GROUP G: GLOBAL ELECTIVES				
Sl. No.	**Host Dept**	**Course Code**	**Course Title**	**Credits**
1.	CS	18CS2G01	Business Analytics	3
2.	CV	18CV2G02	Industrial & Occupational Health and Safety	3
3.	IM	18IM2G03	Modeling using Linear Programming	3
4.	IM	18IM2G04	Project Management	3
5.	CH	18CH2G05	Energy Management	3
6.	ME	18ME2G06	Industry 4.0	3
7.	ME	18ME2G07	Advanced Materials	3
8.	CHY	18CHY2G08	Composite Materials Science and Engineering	3
9.	PHY	18PHY2G09	Physics of Materials	3
10.	MAT	18MAT2G10	Advanced Statistical Methods	3

I Semester		
APPLIED MATHEMATICS (Common to MPD, MMD, MCM, MPE, MBT, MBI, MCH, MST, MHT)		
Course Code: 18MAT11A		**CIE Marks: 100**
Credits: L:T:P:: 4:0:0		**SEE Marks: 100**
Hours: 47		**SEE Duration: 3Hrs**

Course Learning Objectives (CLO):

Students are able to:

1. Adequate exposure to learn statistical techniques, random phenomena for analyzing data to find the suitable mathematical/probability models for solving practical situation in engineering applications.
2. To learn fundamentals of linear algebra, solution of system of linear equations and eigen value problems used in various fields of engineering and science.
3. Explore the possibility of finding approximate solutions using numerical methods in the absence of analytical solutions of various systems.
4. Apply the concepts of optimization to solve engineering applications of optimization which have great importance in the field of engineering.

Unit-I	09 Hrs
Statistics: Method of least squares, fitting of straight line, linearization of nonlinear laws, curve fitting by polynomials, correlation, coefficient of correlation, lines of regression, Spearman rank correlation.	
Unit-II	**09 Hrs**
Probability distributions: Introduction to probability, Random variables-discrete and continuous random variables, important measures and moment generating functions, Standard distributions-Binomial, Exponential, Normal and Gamma distributions.	
Unit -III	**09 Hrs**
System of linear equations and eigen value problems: System of linear equations-LU decomposition and Gauss-Jordan method, Eigen value problems–bounds on eigen values, Power method and Inverse Power method, Eigen values and eigen vectors of real symmetric matrices-Jacobi method.	
Unit -IV	**10 Hrs**
Numerical solution of differential equations: Boundary value problems (IVP & BVP)–finite difference method for linear and nonlinear problems, Shooting method and Galerkin method. Finite difference methods for parabolic, elliptic and hyperbolic partial differential equations, Finite element method and simple problems.	
Unit -V	**10 Hrs**
Engineering optimization: Engineering applications of optimization, statement of an optimization problem-design vector, design constraints, constraint surface, objective function and objective function surface. Multivariable optimization with inequality constraints-Kuhn-Tucker conditions, Constraint qualification, Genetic operators, Neural-Network-based Optimization. Optimization of Fuzzy systems.	

Course outcomes (CO):
On completion of the course, the student should have acquired the ability to CO1: Identify and interpret the fundamental concepts of statistics, distributions, linear algebra, differential equations and optimization arising in various fields engineering. CO2: Apply the knowledge and skills of statistical/numerical/optimization techniques to solve problems of least squares, probability distributions, linear equations, eigen value problems and differential equations. CO3: Analyze the physical problem to establish statistical/mathematical model and use appropriate method to solve and optimize the solution. CO4: Distinguish the overall mathematical knowledge gained to demonstrate the problems of least squares, probability distributions, linear equations, eigen value problems, differential equations and optimization arising in practical situations.

Reference Books:	
1	Theory and Problems of Probability, Schaum's Outline Series, Seymour Lipschutz and Marc lars Lipson, 2nd edition, ISBN: 0-07-118356-6.
2	Introductory method of numerical analysis, S. S. Sastry, 4th edition, 2009, Prentice-Hall India Pvt. Ltd. ISBN : 81-203-1266-X.
3	Numerical methods for scientific and engineering computation, M K Jain, S. R. K. Iyengar, R. K. Jain, 6th edition, 2012, New Age International Publishers, ISBN-13: 978-81-224-2001-2.
4	Engineering Optimization Theory and Practice, Singiresu S. Rao, 3rd Edition, New Age International (P)Ltd., ISBN: 81-224-1149-5.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

MODELLING AND SIMULATION OF PROCESSES (THEORY & PRACTICE)			
Course Code: 18MCH12		**CIE Marks: 100+50**	
Credits: L:T:P: 4:0:1		**SEE Duration: 3 Hrs**	
Hrs:50		**SEE Marks: 100+50**	
Unit – I			**10Hrs**
Introduction: Models and model building. Lumped parameter models (steady-state and unsteady-state). Distribution parameter models (steady-state and unsteady state) Stochastic models- discrete state/continuous state. Parameter estimation			
Unit – II			**09Hrs**
Modeling of Chemical Engineering Systems: Scope and coverage, scope and principle, equation of motion, transport equations, Equations of state, equilibrium and chemical kinetics.			
Unit – III			**11Hrs**
Models for Chemical Engineering Systems: CSTR- Isothermal, constant and variable holdup, two heated tanks, pressurized CSTR, Batch Reactor, Reactor with Mass transfer			
Unit – IV			**10Hrs**
Multivariable Processes**:** Matrix Properties and state properties, Transpose, inversion, Eigen Values, Canonical Transformation, Singular Values			
Unit – V			**10Hrs**
Numerical analysis for simulation: Introduction to simulation, Role of computers and numerical methods in simulation, Iterative convergence methods, explicit convergence, Wegstein and Muller methods, explicit numerical integration algorithms, implicit methods. Numerical examples.			
Unit – VI (Lab Component)			
1. Cooling Tower 2. Distillation Column 3. Ethanol Plant 4. Atmospheric crude distillation 5. Multistage Crosscurrent Adsorption System 6. Reactors in series 7. Reactors in parallel 8. Combination of reactors			
Course Outcomes: After going through this course the student will be able to: CO1: Understand the principles of modeling and simulation CO2:Apply mathematical tools to solve model equations CO3:Analyze chemical engineering systems for model development CO4:Develop mathematical models for simple chemical engineering systems			
Reference Books:			
1	William L. Luyben, Process Modeling, Simulation, and Control for Chemical Engineers, 2nd Edition, McGraw-Hill1989, ISBN:0070391599		
2	Ramirez W.F., Computational Methods for Process Simulation,2nd Edition, Butterworth, 1998,ISBN:9780080529691		
3	Franks R.E., Modeling and Simulation in Chemical Engineering, John Wiley, 1972,ISBN:0471275352		
4	Gaikwad R.W, and Dhirendra, Process Modelling and Simulation, 2nd Edition, Denetted & Co., 2006,ISBN: 8190322826		

Scheme of Continuous Internal Evaluation (CIE): Theory for 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Scheme of Continuous Internal Evaluation (CIE): Practical Test for 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

Scheme of Semester End Examination (SEE): Theory for 100 marks

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Scheme of Semester End Examination (SEE); Practical Exam for 50 Marks

SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester End Evaluation (SEE): Theory (100 Marks) + Practical (50 Marks) = Total 150 Marks

PROCESS EQUIPMENT DESIGN			
Course Code: 18MCH13		**CIE Marks:75+25**	
Credits: L:T:P: 4:0:1		**SEE Marks: 100**	
Hrs: 48		**SEE Duration: 3 Hrs**	
Each design to be taught for 8 hours			**48Hrs**

Detailed Engineering Process & Mechanical Design Aspects and sketching (The sketch shall include sectional front view, full Top/side view) of the following:

1. Shell and Tube Exchanger.
2. Horizontal and Vertical Condensers
3. Evaporator Single Effect
4. Bubble Cap Distillation Column
5. Packed bed Absorption Column
6. Crystalliser

   Students will prepare detailed drawing of individually allotted equipment and submit these results as part of the assignment which will be evaluated.

Course Outcomes: After going through this course the student will be able to:

CO1:Understand design procedure of process equipments

CO2:.Apply chemical engineering principles to design process equipments

CO3:Estimate physical dimensions of various parts of chemical process equipments and accessories

CO4:Analyze various design options at all design stages

Reference Books:

1.	R.H.Perry and D.W.Green, Chemical Engineers Handbook, McGraw Hill, 7th Edition, 1998, ISBN 0-07-115982-7
2	J.M.Coulson and J.F.Richardson, Chemical Engineering, Pregman Press, Vol.6, 3rd Edition 1993, ISBN:10-0750641428
3	Brownell and Young: Process Equipment Design - Vessel Design, John Willey, Published 1951, ISBN:0471113190
4	M.V.Joshi, Process Equipment Design,3rd Edition, Macmillan and Co. India, Delhi, Reprint 1998, ISBN 023-063-810-4

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of tests and assignments. Three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 75. Five assignments are given for 10 marks each and the sum of the marks scored from five assignments is reduced to 25.

Total CIE is 75+25=100 Marks

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The question paper consists of two questions carrying 100 marks for the design and detailed sketch of equipment. Student is required to answer any one. There shall not be split of equipments among the questions.

Semester: I						
PROFESSIONAL SKILL DEVELOPMENT (Common to all Programs)						
Course Code	**:**	**18HSS14**		**CIE Marks**	**:**	**50**
Credits: L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**Audit Course**
Hours	**:**	**18L**				

Unit – I	**03 Hrs**
Communication Skills: Basics of Communication, Personal Skills & Presentation Skills – Introduction, Application, Simulation, Attitudinal Development, Self Confidence, SWOC analysis. **Resume Writing:** Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts. Theory and Applications.	
Unit - II	**08 Hrs**
Quantitative Aptitude and Data Analysis: Number Systems, Math Vocabulary, fraction decimals, digit places etc. Simple equations – Linear equations, Elimination Method, Substitution Method, Inequalities. **Reasoning** – a. **Verbal** - Blood Relation, Sense of Direction, Arithmetic & Alphabet. b. **Non- Verbal reasoning** - Visual Sequence, Visual analogy and classification. **Analytical Reasoning** - Single & Multiple comparisons, Linear Sequencing. **Logical Aptitude** - Syllogism, Venn-diagram method, Three statement syllogism, Deductive and inductive reasoning. Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. **Verbal Analogies/Aptitude** – introduction to different question types – analogies, Grammar review, sentence completions, sentence corrections, antonyms/synonyms, vocabulary building etc. Reading Comprehension, Problem Solving	
Unit - III	**03 Hrs**
Interview Skills: Questions asked & how to handle them, Body language in interview, and Etiquette – Conversational and Professional, Dress code in interview, Professional attire and Grooming, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on Stress Interviews, Technical Interviews, and General HR interviews	
Unit - IV	**02 Hrs**
Interpersonal and Managerial Skills: Optimal co-existence, cultural sensitivity, gender sensitivity; capability and maturity model, decision making ability and analysis for brain storming; Group discussion(Assertiveness) and presentation skills	
Unit - V	**07 Hrs**
Motivation: Self-motivation, group motivation, Behavioral Management, Inspirational and motivational speech with conclusion. (Examples to be cited). **Leadership Skills:** Ethics and Integrity, Goal Setting, leadership ability.	

Course Outcomes: After going through this course the student will be able to:	
CO1	Develop professional skill to suit the industry requirement.
CO2	Analyze problems using quantitative and reasoning skills
CO3	Develop leadership and interpersonal working skills.
CO4	Demonstrate verbal communication skills with appropriate body language.

Reference Books:	
1.	The 7 Habits of Highly Effective People, Stephen R Covey, 2004 Edition, Free Press,ISBN: 0743272455
2.	How to win friends and influence people, Dale Carnegie, 1st Edition, 2016, General Press, ISBN: 9789380914787
3.	Crucial Conversation: Tools for Talking When Stakes are High, Kerry Patterson, Joseph Grenny, Ron Mcmillan 2012 Edition, McGraw-Hill Publication ISBN: 9780071772204
4.	Ethnus, Aptimithra: Best Aptitude Book, 2014 Edition, Tata McGraw Hill ISBN: 9781259058738

Scheme of Continuous Internal Examination (CIE)
Evaluation of CIE will be carried out in TWO Phases.

Phase	**Activity**
I	After 9 hours of training program, students are required to undergo a test set for a total of 50 marks. The structure of the test will have two parts. Part A will be quiz based evaluated for 15 marks and Part B will be of descriptive type, set for 50 Marks and reduced to 35 marks. The total marks for this phase will be 50 (15 + 35).
II	Similarly students will have to take up another test after the completion 18 hours of training. The structure of the test will have two parts. Part A will be quiz based evaluated for 15 marks and Part B will be of descriptive type, set for 50 Marks and reduced to 35 marks. The total marks for this phase will be 50 (15 + 35).
FINAL CIE COMPUTATION	
Continuous Internal Evaluation for this course will be based on the average of the score attained through the two tests. The CIE score in this course, which is a mandatory requirement for the award of degree, must be greater than 50%. Needless to say the attendance requirement will be the same as in any other course.	

SOLID WASTE MANAGEMENT Group-A: Core Electives		
Course Code:18MCH1A1		**CIE Marks:100**
Credits : L:T:P: 4:0:0		**SEE Duration:3Hrs**
Hrs:50		**SEE Marks:100**

Unit – I	10 Hrs
Functional elements, Philosophy and organization, Status of solid waste management, Integrated waste management strategy. Legislation and Government agencies, Planning solid waste management. Transport - collection systems, collection equipment, transfer stations, collection route optimization, Onsite handling, Collection SCS, HCS, and separation processes, source reduction, Storage and processing, Transfer and transport	
Unit – II	10 Hrs
Processing techniques and equipment. Biochemical Conversion: Composting - Aerobic composting. Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Types of biogas plants, Community biogas plants Thermal conversion techniques Pyrolysis, Gasification, waste to energy Generation Sources of energy generation, Gasification; Types of gasifiers; Industrial applications of gasifiers, Briquetting; Utilization and advantages of briquetting; Refuse derived Fuel.	
Unit – III	09 Hrs
Waste disposal options - Disposal in landfills - Landfill Classification, types and methods - site selection - design and operation of sanitary landfills, secure landfills - leachate and landfill gas management - landfill closure and environmental monitoring - closure of landfills - landfill remediation Incineration; Furnace type & design; Medical / Pharmaceutical waste incineration; Environmental impacts; Measures of mitigate environmental effects due to incineration	
Unit – IV	11Hrs
Hazardous waste and their management, Process management issues, Planning. Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste -Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation& Closure. Biomedical (Handling and Management) Rules 2008, sources, treatment and disposal, E Waste Management	
Unit – V	10Hrs
Case studies on major industrial solid waste generation units- Coal fired power plant, Textile industry, Brewery, Distillery, Oil refinery, Radioactive generation units. Oil spills. Recent Developments in Solid Wastes Reuse and Disposal: Power Generation, Blending with construction materials and Best Management Practices (BMP), Role of various organizations in Solid Waste Management – Governmental, Non-Governmental, Citizen Forums.	
Course Outcomes: After going through this course the student will be able to: CO1: Understand the importance of waste reduction at source. CO2: Apply the principles of existing and emerging technologies to convert waste to value added products CO3: Analyze and select appropriate waste management techniques CO4: Develop solid waste management scheme for an urban area	
Reference Books:	

1.	George Tchobanoglous, Integrated Solid Waste Management, McGraw-Hill Publishers, 2003,ISBN:0070632375
2.	B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, Waste Management, Springer, 2004, ISBN:9783642082122
3.	Jagbir Singh, and A.L. Ramanathan, Solid Waste Management Present and Future Challenges, I.K. International House Pvt. Ltd., New Delhi, 2010,ISBN:9789380026428

4.	R.E.Landreth and P.A.Rebers, Municipal Solid Wastes – problems and Solutions, Lewis Publishers, 2002, ISBN:9781566702157

Scheme of Continuous Internal Evaluation (CIE): Theory for 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Scheme of Semester End Examination (SEE): Theory for 100 marks

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

FUEL CELL TECHNOLOGY Group-A: Core Electives		
Course Code:18MCH1A2		**CIE Marks:100**
Credits : L:T:P:4:0:0		**SEE Duration:3 Hrs**
Hrs:50		**SEE Marks :100**

Unit – I	10Hrs
Hydrogen characteristics and importance, conventional and non-conventional methods of hydrogen production, hydrogen storage, handling and safety	
Unit – II	09Hrs
Introduction, fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, open circuit voltage, fuel cell reactions, fuels for cells and their properties, balance of plant and Fuel Cell reaction kinetics, activation kinetics and electrode kinetics	
Unit – III	10Hrs
Classification of fuel cells, alkaline fuel cell, direct methanol fuel cell, phosphoric acid fuel cell, fabrication, advantages, disadvantages and applications	
Unit – IV	11Hrs
Solid oxide fuel cell, proton exchange membrane fuel cell, molten carbonate fuel cell, fabrication, advantages, disadvantages and applications	
Unit – V	10Hrs
Fuel Cell Characterization, current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques	

Course Outcomes: After going through this course the student will be able to:

CO1: Understand the concepts of fuel cells and their kinetics.

CO2 :Apply thermodynamics and chemical engineering principles to evaluate performance of a fuel cell

CO3: Analyze the performance of various fuel cells based on efficiencies and characteristics

CO4 :Develop new components or alternative materials for existing fuel cells

Reference Books:

1.	Viswanathan and M Aulice Scibioh; Fuel Cells – Principles and Applications, Universities Press; First Edition, reprinted in 2009, ISBN 9781420060287
2.	James Larminie and Andrew Dicks, Fuel Cell Systems Explained; John Wiley & Sons; Second Edition, 2003, ISBN 9780768012590
3.	O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY, First Edition (2006), ISBN 9780470258439
4.	Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. First Edition (2007), ISBN 9780387688152

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum.

of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new

developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

PIPING ENGINEERING Group-A: Core Electives		
Course Code :18 MCH1A3		**CIE Marks:100**
Credits: L:T:P:4:0:0		**SEE Duration:3 Hrs**
Hrs:44		**SEE Marks :100**

Unit – I 08Hrs

Fundamentals of Fluid Mechanics: Euler's equation of motion, continuity equation, Bernoulli's equation, gas laws.

Hydraulic Design Considerations: Determination of pipe size, determination of pressure losses, thrusts in pipe lines, design of gas pipe lines, measurement of flow in pipes.

Metallurgy of Piping Materials: Selection of piping materials, physical properties of pipe materials, alloying elements in steel, recommended piping materials.

Unit – II 10Hrs

Pipes and Pipe Fittings: Standards and specifications, steel pipes, steel pipe fittings, cast iron pipes, cast iron fittings, jointing of cast iron pipes, tubes of other materials, design of flanges and flanged pipes.

Valves and Allied Fittings: Valves, functions of valves, valve materials and methods of construction, pressure drop in valves, valve size, types of valves, valve fittings

Unit – III 10Hrs

Pipe Supports: Load on structural supports, supporting structures of pipe lines, pipe supports- design considerations, platforms and ladders, foundation, supporting span of overhead pipelines, stiffening ribs, pipe clamping, flexible hanger supports.

Unit – IV 08Hrs

Piping Fabrication: Codes and standards, piping fabrication, welding joints in pipe lines, welding processes used in piping fabrication, preparation of pipe edges, welding electrodes, heat treatment of weld joints, inspection of weld joints, repair of defective weld joints, acceptance standards.

Corrosion Erosion in Pipelines: Corrosion control in a critical task, corrosion process, corrosion reaction, types of corrosion, anticorrosive protective coatings, cathodic protection of pipelines, abrasion.

Unit – V 08Hrs

Expansion Effects and Compensating Methods: Pipe expansions, methods of compensation, thermal force calculation, methods of compensation, permissible equivalent stresses caused by' additional external loads expansion devices calculation of anchor force using a bellow below material and life, use of hinged compensators. **Thermal Insulation:** Functions of thermal insulators, modes of heat transfer, insulating materials, temperature drop in a pipeline, application of insulation, calculation of condensate, desuperheaters.

Reference Books

1.GK. Sahu, "Handbook of Piping Design", 2nd Edition, New Age Publishers, 1998. ISBN-10: 8122424562

2.Mohinder L. Nayyar, "Piping Hand Book", 7th Edition, Mc. Graw Hill Publication, 1996, ISBN-13: 978-0070471061

Course outcomes:

After completion of the course student will be able to:

CO1: Recall the fundamentals of fluid flow, heat transfer, insulation and corrosion.

CO2: Calculate pressure losses in pipes and describe the different methods for determining the pipe size.
CO3: Apply the concept of fluid flow, heat transfer, insulation and corrosion for design of pipelines.
CO4: Compare and distinguish amongst various alloying elements, materials of construction, pipe fittings, supports, expansion devices and materials of insulation.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

RENEWABLE ENERGY RESOURCES & SYSTEMS Group-B: Core Elective		
Course Code:18MCH1B1		**CIE Marks:100**
Credits : L:T:P: 4:0:0		**SEE Duration:3 Hrs**
Hrs:50		**SEE Marks :100**

Unit – I	**10Hrs**
Introduction: Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil Shale, Nuclear energy Option	
Unit – II	**11Hrs**
Solar Energy: Solar radiation: measurements and prediction. Solar thermal collectors- flat plate collectors, concentrating collectors. Basic theory of flat plate collectors, solar heating of buildings, solar still, solar water heaters, solar driers; conversion of heat energy in to mechanical energy, solar thermal power generation systems. Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications :battery charger, domestic lighting, street lighting, water pumping, power generation schemes	
Unit – III	**09Hrs**
Wind Energy: Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Betz limit, WECS: classification, characteristics, and applications	
Unit – IV	**10Hrs**
Ocean Energy: Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems- ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.	
Unit – V	**10Hrs**
Other Sources: Hydropower, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; Magneto-hydro-dynamic (MHD) energy conversion.	

Course Outcomes:

After going through this course the student will be able to:
CO1: Understand the importance of various renewable energy sources
CO2: Apply the principles of existing and emerging technologies to harness renewable energy
CO3: Analyze the performance of renewable energy systems
CO4: Develop power generation schemes using renewable energy systems

Reference Books:

1	D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia 2000, ISBN: 9781560327141
2	C. S. Solanki, Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009, ISBN:9788120343863
3	L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990, ISBN:9780139605277
4	David &Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press,1994, ISBN:9780791812051
5	S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill ,1984, ISBN: 1259081966

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

INDUSTRIAL WASTEWATER TREATMENT Group-B: Core Elective		
Course Code:18MCH1B2		**CIE Marks:100**
Credits : L:T:P: 4:0:0		**SEE Duration:3 Hrs**
Hrs:50		**SEE Marks:100**

Unit – I	**10Hrs**

Characteristics of Industrial Wastewater:
Physical characteristics: color, odor, temperature, turbidity, total solids. Chemical characteristics: inorganic and organic characteristics and their determination. Biological characteristics: Classification of microorganisms, pathogenic organisms, Toxicity, Analysis of solids data. Measurement of organic matter, Modeling of BOD reaction, Estimation of BOD, COD.

Unit – II	**10Hrs**

Physico - Chemical Treatment:
Introduction to wastewater treatment methods and steps. Screens, Grit chamber, Comminutors, Flow Equalisation. Selection of treatment process and basic design considerations. Sedimentation: theory, types and design. Principle of Coagulation and Flocculation: types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant, design criteria and numerical examples.

Unit – III	**09Hrs**

Bio - Chemical Treatment:
Biological process for wastewater treatment. Microbial growth kinetics, Suspended and attached growth processes - Aerobic and Anaerobic. Activated Sludge Process, Extended Aeration, Contact Stabilization, sludge blanket systems, Rotating Biological Contactors. Management of sludge: Thickening, Digestion, Dewatering, Sludge drying and Composting.

Unit – IV	**11Hrs**

Advanced Treatment:
Disinfection: different methods, disinfectants, factors affecting disinfection. Chlorination: classification, dechlorination. Water Softening – Ions causing hardness, Membrane Technologies; Microfiltration, Ultra filtration, Nanofiltration and Reverse Osmosis, Solar Evaporation Pans, Ion Exchange process, Nitrogen and phosphorous removal

Unit – V	**10Hrs**

Effluent Treatment Plants:
CPCB guidelines and standards for effluent treatment and disposal, Effluent treatment plant of typical chemical industries: Sugar, Dairy, Distillery, Textile, and Pharmaceutical industries.
Operation and Maintenance of ETPs: Factors affecting operation and Maintenance of ETPs, Control and Monitoring of ETPs

Course Outcomes:
After going through this course the student will be able to:
CO1: Understand the importance of wastewater management
CO2: Apply the physico-chemical and biological principles to treat industrial wastewater
CO3: Analyze the performance of various wastewater treatment techniques
CO4: Develop scheme for treating typical industrial effluents

Reference Books:

1	Patwardhan, A.D., Industrial Waste Water Treatment, 2009,Edition, PHI learning, ISBN: 978-81-203-3350-5
2	Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 2013 Edition, McGraw-Hill Science/Engineering/Math ISBN:978 0073401188
3	Wesley Eckenfelder, W Industrial water pollution control, 2000 Edition, Tata McGraw-Hill Publishing Company Ltd., ISBN:7302051348
4	NG WunJern, Industrial Wastewater Treatment, 2006 Edition, Imperial College Press, ISBN 1-86094-580-5

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

INTERFACIAL PHENOMENA AND SURFACE ENGINEERING (Group-B: Core Elective)		
Course Code:18MCH1B3		**CIE Marks:50**
Credits : L:T:P: 4:0:0		**SEE Duration:3 Hrs**
Hrs:50		**SEE Marks:100**

Unit – I	**10Hrs**
Introduction: Various applications, concept of surface as surface of excess energy and surface of tension, equivalence of two concepts with examples, pressure tensor.	
Unit – II	**09Hrs**
Excess Pressure: Generalized equation for pressure jump across a curved surface, pressure jump cylindrical surfaces, zero pressure jump surface; vapor pressure a drop, solubility of a drop, ostwald ripening and its prevention, capillary condensation, super saturation, nucleation, superheating	
Unit – III	**11Hrs**
Measurement of Interfacial Tension: Capillary rise method, drop weight method, Wilhelm plate method, Du nuoy ring method. Thermodynamics of interfaces, temperature and pressure effects, work of adhesion, cohesion, spreading co-efficient. Gibbs treatment of highly non-ideal mixtures. Gibbs isotherm, measurement of surface concentration, validation of gibbs isotherm.	
Unit – IV	**10Hrs**
Three Phase Systems: Neumann triangle, engulfing of one phase by the other, solid-liquid-fluid systems, contact angle, advancing and receding contact angles, detergency, intermolecular forces – forces between molecules, three components of vander walls forces, forces between macroscopic bodies, continuum theories, deryaguin's approximation.	
Unit – V	**10Hrs**
Electrical Double Layer: In a charged plate immersed in an electrolyte solution, repulsive pressure due to overlapping of electrical double layer, origin of repulsive force – entopic, total interaction energy profiles for particles/drops between particles, rate of collision between particles with and without a force field between them, stability factor.	

Course Outcomes: After going through this course the student will be able to

CO1: Understand the concepts of Surface Engineering
CO2: Measure Interfacial Tension based on Thermodynamic principle
CO3: Analyse inter molecular forces in Three Phase system
CO4: Explain Electrical double theory in electrolyte solutions

Reference Books:

1. C.A. Miller & P. Niyogi. 'Interfacial phenomena, Equilibrium and Dynamic Effects', Marshel Deckder, 1985.
2. A.W.Adamson. 'Physical chemistry of surfaces', John Wiley, 5th edition.
3. Milliet.J.L. 'Surface Activity', 2nd edition., Van Nostrad, 1961.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

PLANT WIDE CONTROL OF CHEMICAL PROCESS		
Course Code:18MCH21		**CIE Marks:100 + 50**
Credits : L:T:P: 4:0:1		**SEE Duration: 3 Hrs**
Hrs:50		**SEE Marks:100 + 50**

Unit – I	**10Hrs**
Review of Process Dynamics, first order systems, thermometer, level tank, CSTR, second order system – U tube manometer, mass vibrator and response studies	
Unit – II	**09Hrs**
Feed Back Control, **f**eedback controllers, PID controller design and tuning, Zeigler – Nichols controller tuning Stability**:** Concept and Criterion, Routh test, Root locus, frequency response analysis – Bodediagrams, Phase margin and gain margin	
Unit – III	**11Hrs**
Advanced control techniques, **c**ascade, feed-forward and feed-backward, ratio control, selective and adaptive control, smith predictor and internal module controller.	
Unit – IV	**10Hrs**
Multi variable controller, **f**eatures and examples of multi input and multi output processes, design of cross controller, relative gain array, Niderlinski index Control Structures for unit operations, **s**imple distillation column, heat exchanger, evaporator, and reactor	
Unit – V	**10Hrs**
Plant wide control for improved economics, **p**rocess operation for a given throughput and for maximum throughput, concept of bottleneck constraint, application of optimizing controllers for throughput maximization on case study processes	

Course Outcomes: After going through this course the student will be able to:

CO1: Recall the concepts of process dynamics.
CO2: Explain control mechanism in chemical process
CO3: Apply various control techniques for process parameters
CO4: Analyze the stability of chemical process.

Reference Books:

1.	G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, 1st ed. New Delhi: Prentice-Hall of India, 1984, ISBN 0-81-203-0665-1.
2.	Ray Ogunnaike, Babatunde Ayodeji Ogunnaike, Willis Harmon Ray, Process Dynamics, Modeling, and Control, Oxford University Press, 1994, ISBN: 0195091191, 9780195091199
3.	C. Branan, Rules of Thumb for Chemical Engineers: A manual of quick, accurate solutions to everyday process engineering problems, 4th ed. Noida: Elsevier, 2008; ISBN 978-0-7506-7856-8
4.	W.L. Luyben, M.L. Luyben, Essentials of Process Control, Int. ed. Singapore: McGraw-Hill, 1997.
5.	C.A. Smith, A.B. Corripio, Principles and Practice of Automatic Process Control, 1st ed. John Wiley & Sons, USA, 1991, ISBN 0-471-88346-8.

Scheme of Continuous Internal Evaluation (CIE): Theory for 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Scheme of Continuous Internal Evaluation (CIE): Practical Test for 50 Marks
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

Scheme of Semester End Examination (SEE): Theory for 100 marks
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Scheme of Semester End Examination (SEE); Practical Exam for 50 Marks
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester End Evaluation (SEE): Theory (100 Marks) + Practical (50 Marks) = Total 150 Marks

HETEROGENEOUS REACTION SYSTEMS			
Course Code:18MCH22		**CIE Marks:100**	
Credits : L:T:P: 4:0:0		**SEE Duration:3 Hrs**	
Hrs:50		**SEE Marks:100**	
Unit – I			**10Hrs**
Non ideal reactor analysis, mixing concepts, Residence Time Distribution, response measurements, segregated flow model, Dispersion model, series of stirred tanks model, analysis of non-ideal reactors and two parameter model			
Unit – II			**10Hrs**
Non-catalytic Heterogeneous Reactions, **i**ntroduction, fluid-fluid reactions, fluid-solid reactions & models to determine time of conversion **C**lassification of catalysts, preparation of catalysts, catalyst supports			
Unit – III			**10Hrs**
Catalyst Characterization, **s**urface area measurements, BET theory, pore size distribution, porosity - chemisorption techniques, crystallography and surface analysis techniques.			
Unit – IV			**10Hrs**
Catalytic Heterogeneous Reactions, **c**atalytic reactions, rate controlling steps, Langmuir - Hinshelwood model, Eiley - Riedel mechanism Catalyst deactivation, poisons, sintering of catalysts, kinetics of deactivation.			
Unit – V			**10Hrs**
External diffusion effects in Heterogeneous Reactions, surface kinetics and pore diffusion effects, Effectiveness factor Rreactors for heterogeneous catalytic & non-catalytic reactions			
Course Outcomes: After going through this course the student will be able to: CO1: Apply principles of transfer operation in kinetics studies of heterogeneous reaction systems CO2: Analyze complex chemical reaction mechanisms and kinetics CO3:Develop rate equations for catalytic reaction systems CO4: Evaluate the performance of reactors for multiphase reaction systems			
Reference Books:			
1.	Smith J.M, Chemical Engineering Kinetics, 3rd Edition, McGraw- Hill, 1984, ISBN:0071247084		
2	Bischoff and Froment, Chemical Reactor Design and Analysis, Addision Wesley, 1982, ISBN:9780471024477		
3	Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall, 1986.ISBN: 978-0137146123		
4	Octave Levenspiel, Chemical Reaction Engineering 3 rd Edition ,John wiley and sons, ISBN: 9780471254249		

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems

2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
RESEARCH METHODOLOGY (Common to all programs)						
Course Code	**:**	**18IM23**		**CIE Marks**	**:**	**100**
Credits	**:**	**L: T: P**	**3:0:0**	**SEE Marks**	**:**	**100**
Hours	**:**	**36**		**SEE Duration**	**:**	**3 hours**

Unit – I	
Overview of Research: Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, completely randomized, randomized block, Latin Square, Factorial.	**07 Hrs**
Unit – II	
Data and data collection: Overview of probability and data types Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **Sampling Methods:** Probability sampling and Non-probability sampling	**08 Hrs**
Unit – III	
Processing and analysis of Data: Statistical measures of location, spread and shape, Correlation and regression, Hypothesis Testing and ANOVA. Interpretation of output from statistical software tools	**07 Hrs**
Unit – IV	
Advanced statistical analyses: Non parametric tests, Introduction to multiple regression, factor analysis, cluster analysis, principal component analysis. Usage and interpretation of output from statistical analysis software tools.	**07 Hrs**
Unit-V	
Essentials of Report writing and Ethical issues: Significance of Report Writing , Different Steps in Writing Report, Layout of the Research Report , Ethical issues related to Research, Publishing, Plagiarism **Case studies:** Discussion of case studies specific to the domain area of specialization	**07 Hrs**

Course Outcomes: After going through this course the student will be able to	
CO1	Explain the principles and concepts of research types, data types and analysis procedures.
CO2	Apply appropriate method for data collection and analyze the data using statistical principles.
CO3	Present research output in a structured report as per the technical and ethical standards.
CO4	Create research design for a given engineering and management problem situation.

Reference Books:	
1	Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 4th edition, ISBN: 978-93-86649-22-5
2	Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi, 2006. ISBN: 978-81-77585-63-6
3	William M. K. Trochim, James P. Donnelly, The Research Methods Knowledge Base, 3rd Edition, Atomic Dog Publishing, 2006. ISBN: 978-1592602919
4	Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems

2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
MINOR PROJECT (Common to all Programs)						
Course Code	**:**	**18MCH24**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**0:0:4**		**SEE Marks**	**:**	**100**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hrs**

GUIDELINES
1. Each project group will consist of maximum of two students. 2. Each student / group has to select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey. 3. Allocation of the guides preferably in accordance with the expertise of the faculty. 4. The number of projects that a faculty can guide would be limited to four. 5. The minor project would be performed in-house. 6. The implementation of the project must be preferably carried out using the resources available in the department/college.

Course Outcomes: After completing the course, the students will be able to	
CO1	Conceptualize, design and implement solutions for specific problems.
CO2	Communicate the solutions through presentations and technical reports.
CO3	Apply resource managements skills for projects.
CO4	Synthesize self-learning, team work and ethics.

Scheme of Continuous Internal Examination

Evaluation will be carried out in 3 phases. The evaluation committee will comprise of 4 members: Guide, Two Senior Faculty Members and Head of the Department.

Phase	Activity	Weightage
I	Synopsys submission, Preliminary seminar for the approval of selected topic and objectives formulation	20%
II	Mid term seminar to review the progress of the work and documentation	40%
III	Oral presentation, demonstration and submission of project report	40%

** Phase wise rubrics to be prepared by the respective departments

CIE Evaluation shall be done with weightage / distribution as follows:

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/ experimental setup 25%
- Conducting experiments/ implementation / testing 25%
- Demonstration & Presentation 15%
- Report writing 25%

Scheme of Semester End Examination (SEE):

The evaluation will be done by ONE senior faculty from the department and ONE external faculty member from Academia / Industry / Research Organization. The following weightages would be given for the examination. Evaluation will be done in batches, not exceeding 6 students.

- Brief write up about the project 05%
- Presentation / Demonstration of the Project 20%
- Methodology and Experimental results & Discussion 25%
- Report 20%
- Viva Voce 30%

FLUIDISATION ENGINEERING (Elective C: Core Elective)		
Course Code :18MCH2C1		**CIE Marks:100**
Credits : L: T: P:4:0:0		**SEE Duration:3 Hours**
Hrs:47		**SEE Marks :100**

Unit – I	10Hours
Introduction to fluidization and applications Phenomenon of fluidization, behaviour of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons	
Unit – II	9Hours
Mapping of fluidization regimes characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption	
Unit – III	10Hours
Bubbling fluidized beds Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model	
Unit – IV	8Hours
Solids movement and Gas dispersion Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.	
Unit-V	10Hours
Fluidized bed reactors Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds. Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size	

Course Outcomes: At the end of the course, the student will be able to:
CO1. Understand the behavior fluidization in fluidized bed
CO2. Evaluate the characterization of particles in fluidization regimes
CO3. Estimate the power consumption in fluidised bed reactor
CO4. Design fluidized bed reactors in chemical industries

Reference Books

1. Levenspiel O. and Kunnii D., “Fluidization Engineering”, John Wiley, 1972,
ISBN: 9780409902334
2. Liang-Shih Fan, “Gas-Liquid-Solid Fluidization Engineering”, Butterworths, 1989,
ISBN-13: 9780409951790

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

OIL AND GAS PROCESSING (Elective C: Core Elective)		
Course Code :18MCH2C2		**CIE Marks:100**
Credits : L: T: P: 4:0:0		**SEE Duration:3 Hours**
Hrs:48		**SEE Marks:100**

Unit – I	**10Hours**
Lube oil processing, Propane de-asphalting, Solvent Extraction, Dewaxing, Finishing Processes, Lube oil additives, Properties of Bitumen, Methods of Manufacture of Bitumen Product Blending, Hydrogen Production, Sulphur Recovery, Control of air and water pollution, solid waste management	
Unit – II	**9Hours**
Two phase oil and gas separation equipment, types, construction detail, working principle, internal sizing, theory of separation and detail design of separator. Three phase separators, types, construction detail, working principle, vessel internal and control equipment. Theory and sizing of three phase separator. Filters, Vacuum towers.	
Unit – III	**10Hours**
Theory of emulsion and demulsifies, treating system, equipment, sizing and heat calculations. Electronic coalescesers. Skimmer tanks, skimmer sizing equations and produced water treating system. Crude stabilization unit. Environmental problems during separation (ETP) and solutions. Storage of crude oil. Types of tanks, Evaporation loss, safety systems. Safety during processing of oil and gas at onshore & offshore.	
Unit – IV	**9Hours**
Gas liquid separations, dehydration processes, absorption and adsorption by gas permeation. Desulfurization processes, solid bed sweetening process, physical and chemical absorption processes, Acid gas removal. Integrating natural gas processing Introduction, types of compressors, Selection, Thermodynamics of compressors	
Unit-V	**10Hours**
Corrosion mechanism and influencing factors, corrosion preventive methods, chemical inhibitors, Cathodic protection, protective coating s and plastics, removal of corrosion gases and selection of appropriate materials for preventing corrosion.	

Course Outcomes: At the end of the course, the student will be able to:
CO1. Understand working principle for design of separators
CO2. Apply various techniques for the separation of oil-water emulsion.
CO3. Analyze performance of oil pipeline corrosion preventive measures
CO4. Develop methods to process and transport gas

Reference Books:

1.	Bhaskararao, B.K, 'Modern Petroleum Refining Processes', Oxford and IBH Publishing Co. Pvt. Ltd., Fifth Edition, 2008, ISBN: 9788120417151, 8120417151.
2.	Gary, J.H and Handework, G.E., 'Petroleum Refining Technology and Economics', Marcel Dekker, Inc., Fifth Edition, 2007, ISBN 9780849370380.
3.	Ram Prasad, 'Petroleum Refining Technology', Khanna Publishers, First Edition, 2015, ISBN-10: 8174090649
4.	BahaduriAlireza, 'Natural Gas Processing: Theory and Engineering Design', Gulf Publishing Company, First Edition , 2014, **I**SBN**:** 9780080999715.
5.	Fahim, M.A., Alsahhaf, T.A. and Elkilani, A. 'Fundamentals of Petroleum Refining', Elsevier, First Edition , 2010, ISBN**:** 9780444527851.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt

innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

BIO CHEMICAL ENGINEERING (Elective C: Core Elective)				
Course Code :18MCH2C3		**CIE Marks**	**:**	**100**
Credits : L: T: P: 4:0:0		**SEE Duration**	**:**	**3 Hours**
Hrs:48		**SEE Marks**	**:**	**100**

Unit – I	**08Hours**
Microbiology: Scope, Classification of microorganisms, Whitaker's 5–Kingdom concept. Prokaryotic cells: structure, Classification and reproduction in bacteria. Eukaryotic cells: structure, Classification and reproduction in Fungi, Yeasts, molds. Biochemistry**:** Cell construction, Amino acids and proteins, Carbohydrates: Mono and polysaccharides, Nucleic acids, RNA and DNA, Lipids, fats, steroids, Cell nutrients	
Unit – II	**9Hours**
Enzyme Catalyzed Reactions: Introduction, Enzyme kinetics, MM, BH approach, evaluation of kinetic parameters. **Enzyme Inhibitors:** Types of inhibitors, Effects of temperature and pH, Enzyme immobilization, methods of immobilization.	
Unit – III	**10Hours**
Stoichiometry of Cell Growth and Product Formation: Elemental balances, available electron balances, degrees of reduction; yield coefficients of biomass and product formation, maintenance coefficients. **Growth media:** Medium formulation, Oxygen consumption and heat evolution in aerobic cultures.	
Unit – IV	**11Hours**
Kinetics of Microbial Growth and Product Formation: Phases of cell growth and kinetics in batch cultures, Monod and Leudeking-Piret equations, unstructured nonsegrated models to predict specific growth rate, substrate limited growth, models with growth inhibitors. Introduction to structured models, Ideal Bioreactors, Batch reactor, Ideal Chemostat. Sterilization techniques	
Unit-V	**10Hours**
Recovery and purification of products: Removal of microbial cells and other solid matter, foam separation, precipitation, filtration, centrifugation, cell disruption, chemical methods, liquid-liquid extraction, chromatography, membrane separation, drying.	

Course outcomes:

After completion of the course student will be able to:

CO1: Recall the basics of microbiology and enzymes.

CO2: Explain the various product recovery operations

CO3: Analyze the enzyme kinetics and the factors affecting enzyme kinetics

CO4: Predict appropriate sterilization Techniques

Reference Books:

1	Shuler and Khargi, BioProcess Engineering, Basic Concepts, 3rd edition, Prentice Hall, 2017, ISBN-13: 978-0137062706
2	Bailey and Ollis, Biochemical Engineering Fundamentals, 2nd edition,1986, McGraw-Hill Chemical Engineering Series ISBN-13: 978-0070032125
3.	Bioprocess Engineering Principles, 2nd edition, Academic Press, 2012, ISBN: 978-0-12-220851-5
4.	James Lee available as e-book jmlee.org/documents/ebiochesample.pdf

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks

each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

ADVANCED POLYMER COMPOSITES (Elective D: Core Elective)		
Course Code :18MCH2D1		**CIE Marks:100**
Credits : L: T: P: 4:0:0		**SEE Duration:3 Hours**
Hrs: 48		**SEE Marks :100**

Unit – I	**10Hours**
Introduction to Advanced Polymer Composites (APC): Definition, Polymer matrices, Thermoplastics Matrices, Manufacture and properties of PP-PVC- Aramid-PEEK-PPS-Poly sulfone.Thermosetting Matrices: Manufacture and properties of Isophthalic polyester, Epoxy and Polyimide. Elastomeric matrices: Manufacture and properties of PB-SBR	
Unit – II	**9Hours**
Reinforcement fibres: Manufacture and properties of PE fibre/ Nylon/Glass fibres/ Carbon fibres/CNT/Aramid**.**Interface in PMC: Wettability, Types of bonding at the interface, Glass fibre- polymer, Aramid fibre-polymer, PE fibre-polymer	
Unit – III	**10Hours**
Processing of PMC: Thermoplastic matrix composite (Film stacking, Diaphragm forming, Tape laying, Injection moulding, Sheet Molding compound), Thermoset matrix composite (Hand lay-up and spray technique,Filament winding, Pultrusion, Resin transfer moulding, Prepregs).	
Unit – IV	**9Hours**
Designing with composites: Characteristics of composites, Design procedure, Hybrid composite systems, Carbon fibre composites. Fatigue and Creep behavior of PMC. Expressions for Thermal conductivity of composites	
Unit-V	**10Hours**
Testing of PMC: Flexural tests (Single fibre pull out test, Fragmentation test, Laser spallation test). Health and safety methods for PMC. Recycling and disposal methods. Application of PMC: Aircraft, Automotive, and Construction industries, Military, Space and Medical devices.	

Course Outcomes:

After going through this course the students will be able to

CO1: Explain structure of polymer matrix composites from interfacial interaction
CO2: Apply design procedure using composition-property correlation
CO3: Analyze mechanical/thermal performance of polymer matrix composites
CO4: Develop advanced application of polymer matrix composites

Reference Books:

1. Composite Materials- Science and Engineering. Second Edition- Krishnan K Chawla- Springer International edition.ISBN81-8128-490-9
2. Hand book of Polymer science and Technology V-I. M.H.Ferry/A.V.Becker, CBS Publishers and Distributors. ISBN: 81-239-1132-7
3. V.R.Gowarikar, N.V.Viswanathan, Jayadev Sreedhar, “Polymer Science”, New Age International Pvt.Ltd, 2012: ISBN:0-85226-307-4
4. Fried W.Billmeyer, J.R, “Text Book of Polymer Science, Wiley Inter Science”, 3rd Edition: 2005.ISBN:0471-82834-3

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

CHEMICAL PROCESS INTEGRATION (Elective D: Core Elective)		
Course Code: 1**8MCH2D2**		**CIE Marks: 100**
Credits: L:T:P: 4:0:0		**SEE Marks: 100**
Hours: 48		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Identify the possibilities of mass and energy integration
2	Target a specific task by quantification
3	Synthesize alternative routes for integration
4	Analyze the alternatives and generate optimal solution

Unit-I	
Introduction to Process Integration: Process synthesis, process analysis, targeting minimum waste and strategies for targets.	**10 Hrs**
Unit – II	
Graphical Techniques: Sources, sinks, source – sink mapping, pinch diagram for direct-recycle and multi component mapping diagram	**10 Hrs**
Unit -III	
Synthesis of Mass Exchange Networks: Design of individual mass exchangers, mass exchange networks and mass exchange pinch diagram.	**10 Hrs**
Unit –IV	
Algebraic Approach: Algebraic approach to targeting direct recycles and targeting mass exchange. **Heat Integration:** Thermal pinch diagram and minimum utility targeting by algebraic approach.	**10 Hrs**
Unit –V	
Combined Heat and Power Integration: Heat engines, heat pumps, placement of heat engines and heat pumps in heat exchange networks.	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the fundamentals, strategies and approaches of process integration.
CO2:	Apply process integration strategies on chemical engineering systems for mass and utility targeting.
CO3:	Analyze chemical engineering processes to identify limits on process integration.
CO4:	Evaluate purchase/waste/energy minimization in chemical engineering processes.

Reference Books	
1	Process Integration, Mahmoud M El-Halwagi, 1st Edition, 2006, Elsevier Academic Press, ISBN – 13: 978 0 12 370532 7
2	Chemical Process Design and Integration, Robin Smith, 2nd Edition, 2005, John Wiley & Sons, ISBN – 0 471 48681 7
3	Pinch Analysis and Process Integration, Ian C. K., 2nd Edition, 2007, Elsevier BH, ISBN – 13: 978 0 75068 260 2
4	Heat Exchanger Network Synthesis, Shenoy U. V., 1st Edition, 1995, Gulf Professional Publishing, ISBN – 0 884 15391 6

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit

NANOTECHNOLOGY IN CHEMICAL ENGINEERING (Elective D: Core Elective)		
Course Code:18MCH2D3		**CIE Marks:50**
Credits : L:T:P: 4:0:0		**SEE Duration:3 Hrs**
Hrs:48		**SEE Marks:100**

Unit – I	09Hrs

Introduction to nanotechnology: Feynman's Vision-There's Plenty of Room at the Bottom,
Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes,
Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography

Unit – II	09Hrs

Approaches to Synthesis of Nanoscale Materials and characterization
Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down:
Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, spray pyrolysis, ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis using X-ray imaging.
Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM,PSD, Zeta potential, DSC and TGA.

Unit – III	10Hrs

Semiconductors and Quantum dots
Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie'shypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

Unit – IV	10Hrs

Polymer-based and Polymer-filled Nanocomposites
Nanoscale Fillers, Nano fiber or Nanotube Fillers, Plate-like Nano fillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nano composites. Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

Unit – V	10Hrs

Applications to Safety, Environment and Others
Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors,
Nanostructured Materials for Sensing, Waste Water Treatment, Nano biotechnology, Drug Delivery.
Nano coatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nano electronics, Nano machines & nano devices, Societal, Health and Environmental Impacts.

Course Outcomes: After going through this course the student will be able to":
CO1: Understand Physical and chemical deposition techniques in Nano Technology
CO2: To Characterise the synthesized nano materials
CO3: To synthesize semiconductor and polymer based nano materials
CO4: Application of Nanotechnology in Chemical , Biotechnology and safety

Reference Books:

1	A Textbook of Nanoscience and Nanotechnology pradeep T, 2012, Tata McGraw Hill Education Pvt. Ltd. ISBN:9781259007323
2	Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology", Edited byWILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003

3	Kelsall Robert W., Hamley Ian W., GeogheganMark, "Nanoscale Science and Technology" ,John Wiley & Sons, Ltd, 2006.
4	KalRanganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering",McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. The marks component for each assignment is 15 marks. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

BUSINESS ANALYTICS (Group G: Global Elective)						
Course Code	**:**	**18CS2G01**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Course Learning Objectives:

Graduates shall be able to

1. Formulate and solve business problems to support managerial decision making.
2. Explore the concepts, processes needed to develop, report, and analyze business data.
3. Use data mining techniques concepts to identify specific patterns in the data
4. Interpret data appropriately and solve problems from various sectors such as manufacturing, service, retail, software, banking and finance.

Unit – I	
Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling.	**07 Hrs**
Unit – II	
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	**07 Hrs**
Unit – III	
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, Predictive Analytics, Predicative Modelling, Predictive analytics analysis.	**07 Hrs**
Unit – IV	
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.	**08 Hrs**
Unit –V	
Decision Analysis: Formulating Decision Problems, Decision Strategies with and without Outcome, Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Explore the concepts, data and models for Business Analytics.
CO2	Analyze various techniques for modelling and prediction.
CO3	Design the clear and actionable insights by translating data.
CO4	Formulate decision problems to solve business applications

Reference Books:	
1	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Business analytics Principles, Concepts, and Applications FT Press Analytics, 1st Edition, 2014, ISBN-13: 978-0133989403, ISBN-10: 0133989402
2	James Evans, Business Analytics, Pearsons Education 2nd edition, ISBN-13: 978-0321997821

	ISBN-10: 0321997824
3	Evan Stubs , The Value of Business Analytics: Identifying the Path to Profitability, John Wiley & Sons, ISBN:9781118983881 |DOI:10.1002/9781118983881,1st edition 2014
4	Gary Cokins and Lawrence Maisel, Predictive Business Analytics Forward Looking Capabilities to Improve Business, Wiley; 1st edition, 2013.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
INDUSTRIAL AND OCCUPATIONAL HEALTH AND SAFETY (Group G :Global Elective)		
Course Code: 18CV 2G 02		**CIE Marks:100**
Credits : L: T: P : 3:0:0		**SEE Marks :100**
Hours : 36L		**SEE Duration:3Hrs**

Course Learning Objectives :

1	To understand the Industrial and Occupational health and safety and its importance.
2	To understand the different materials, occupations to which the employee can exposed to.
3	To know the characteristics of materials and effect on health.
4	To evaluate the different processes and maintenance required in the industries to avoid accidents.

UNIT – I **7Hrs**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and fire fighting, equipment and methods.

UNIT – II **7Hrs**

Occupational health and safety: Introduction, Health, Occupational health: definition, Interaction between work and health, Health hazards, workplace, economy and sustainable development, Work as a factor in health promotion. Health protection and promotion Activities in the workplace: National governments, Management, Workers, Workers' representatives and unions, Communities, Occupational health professionals. Potential health hazards: Air contaminants, Chemical hazards, Biological hazards, Physical hazards, Ergonomic hazards, Psychosocial factors, Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.

UNIT – III **8Hrs**

Hazardous Materials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids, Gases, Metals and Metallic Compounds, Particulates and Fibers, Alkalies and Oxidizers, General Manufacturing Materials, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents, Noise and Vibration, Temperature and Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses: Stress-Related Health Incidents, Eyestrain, Repetitive Motion, Lower Back Pain, Video Display Terminals.

UNIT – IV **7Hrs**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT – V **7Hrs**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components,
over hauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps,
iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Expected Course Outcomes:
After successful completion of this course the student will be able to:

CO1	Explain the Industrial and Occupational health and safety and its importance.
CO2	Demonstrate the exposure of different materials, occupational environment to which the employee can expose in the industries.
CO3	Characterize the different type materials, with respect to safety and health hazards of it.
CO4	Analyze the different processes with regards to safety and health and the maintenance required in the industries to avoid accidents.

Reference Books:

1.	Maintenance Engineering Handbook, Higgins & Morrow, SBN 10: 0070432015 / ISBN 13: 9780070432017, Published by McGraw-Hill Education. Da Information Services.
2.	H. P. Garg, Maintenance Engineering Principles, Practices & Management, 2009,S. Chand and Company, New Delhi, ISBN:9788121926447
3.	Fundamental Principles of Occupational Health and Safety, Benjamin O. ALLI, Second edition,2008 International Labour Office – Geneva: ILO, ISBN 978-92-2-120454-1
4.	Foundation Engineering Handbook, 2008, Winterkorn, Hans, Chapman & Hall London. ISBN:8788111925428.

Continuous Internal Evaluation (CIE): Total marks: 100
Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
MODELING USING LINEAR PROGRAMMING (Group G: Global Elective)						
Course Code	**:**	**18IM2G03**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Linear Programming: Introduction to Linear Programming problem **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables	**07 Hrs**
Unit – II	
Advanced Linear Programming : Two Phase simplex techniques, Revised simplex method **Duality:** Primal-Dual relationships, Economic interpretation of duality	**07 Hrs**
Unit – III	
Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Post optimal analysis - changes affecting feasibility and optimality	**07 Hrs**
Unit – IV	
Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods, Unbalanced Transportation Problem, Degeneracy in Transportation Problems, Variants in Transportation Problems.	**08 Hrs**
Unit –V	
Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Explain the various Linear Programming models and their areas of application.
CO2	Formulate and solve problems using Linear Programming methods.
CO3	Develop models for real life problems using Linear Programming techniques.
CO4	Analyze solutions obtained through Linear Programming techniques.

Reference Books:	
1	Taha H A, Operation Research An Introduction, PHI, 8th Edition, 2009, ISBN: 0130488089.
2	Philips, Ravindran and Solberg - Principles of Operations Research – Theory and Practice, John Wiley & Sons (Asia) Pvt Ltd, 2nd Edition, 2000, ISBN 13: 978-81-265-1256-0
3	Hiller, Liberman, Nag, Basu, Introduction to Operation Research, Tata McGraw Hill 9th Edition, 2012, ISBN 13: 978-0-07-133346-7
4	J K Sharma, Operations Research Theory and Application, Pearson Education Pvt Ltd, 4th Edition, 2009, ISBN 13: 978-0-23-063885-3.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
PROJECT MANAGEMENT (Group G: Global Elective)						
Course Code	**:**	**18IM2G04**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	**07 Hrs**
Unit – II	
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting	**07 Hrs**
Unit – III	
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	**08 Hrs**
Unit – IV	
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Critical Path Method (CPM), Computerized project management	**07Hrs**
Unit-V	
Project Management and Certification: An introduction to SEI, CMMI and project management institute USA – importance of the same for the industry and practitioners. PMBOK 6 - Introduction to Agile Methodology, Themes / Epics / Stories, Implementing Agile. **Domain Specific Case Studies on Project Management:** Case studies covering project planning, scheduling, use of tools & techniques, performance measurement.	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Explain project planning activities that accurately forecast project costs, timelines, and quality.
CO2	Evaluate the budget and cost analysis of project feasibility.
CO3	Analyze the concepts, tools and techniques for managing projects.
CO4	Illustrate project management practices to meet the needs of Domain specific stakeholders from multiple sectors of the economy (i.e. consulting, government, arts, media, and charity organizations).

Reference Books:	
1	Prasanna Chandra, Project Planning Analysis Selection Financing Implementation & Review, Tata McGraw Hill Publication, 8th Edition, 2010, ISBN 0-07-007793-2.
2	Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Edition, 2013, ISBN: 978-1-935589-67-9
3	Harold Kerzner, Project Management A System approach to Planning Scheduling & Controlling, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
4	Rory Burke, Project Management – Planning and Controlling Techniques, John Wiley & Sons, 4th Edition, 2004, ISBN: 9812-53-121-1

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

II Semester		
ENERGY MANAGEMENT (Group G: Global Elective)		
Course Code: 18CH2G05		**CIE Marks: 100**
Credits: L:T:P: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Hrs: 3**

Course Learning Objectives(CLO):

Students are able to:

5. Explain the importance of energy conservation and energy audit.
6. Understand basic principles of renewable sources of energy and technologies.
7. Outline utilization of renewable energy sources for both domestics and industrial application.
8. Analyse the environmental aspects of renewable energy resources.

Unit-I	08 Hrs
Energy conservation: Principles of energy conservation, Energy audit and types of energy audit, Energy conservation approaches, Cogeneration and types of cogeneration, Heat Exchangers and classification.	
Unit-II	**07 Hrs**
Wet Biomass Gasifiers: Introduction, Classification of feedstock for biogas generation, Biomass conversion technologies: Wet and dry processes, Photosynthesis, Biogas generation, Factors affecting bio-digestion, Classification of biogas plants, Floating drum plant and fixed dome plant their advantages and disadvantages.	
Unit -III	**07 Hrs**
Dry Biomass Gasifiers : Biomass energy conversion routes, Thermal gasification of biomass, Classification of gasifiers, Fixed bed systems: Construction and operation of up draught and down draught gasifiers.	
Unit -IV	**07 Hrs**
Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, Types of solar cells and fabrication. **Wind Energy:** Classification, Factors influencing wind, WECS & classification.	
Unit -V	**07 Hrs**
Alternative liquid fuels: Introduction, Ethanol production: Raw materials, Pre-treatment, Conversion processes with detailed flow sheet. Gasification of wood: Detailed process, Gas purification and shift conversion, Biofuel from water hyacinth.	

Course outcomes (CO):

On completion of the course, the student should have acquired the ability to

CO1: Understand the use alternate fuels for energy conversion

CO2: Develop a scheme for energy audit

CO3: Evaluate the factors affecting biomass energy conversion

CO4: Design a biogas plant for wet and dry feed

Reference Books:

1	Nonconventional energy, Ashok V Desai, 5th Edition, 2011, New Age International (P) Limited, ISBN 13: 9788122402070.
2	Biogas Technology - A Practical Hand Book, Khandelwal K C and Mahdi S S, Vol. I & II, 1986, McGraw-Hill Education, ISBN-13: 978-0074517239.

3	Biomass Conversion and Technology, Charles Y Wereko-Brobby and Essel B Hagan, 1st Edition, 1996, John Wiley & Sons, ISBN-13: 978-0471962465.
4	Solar Photovoltaics: Fundamental Applications and Technologies, C. S. Solanki, 2nd Edition, 2009, Prentice Hall of India, ISBN:9788120343863.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
INDUSTRY 4.0 **(Group G: Global Elective)**						
Course Code	**:**	**18ME2G06**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2M Learning and Artificial Intelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.	**07 Hrs**
Unit – II	
The Concept of the IIoT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture.	**07 Hrs**
Unit – III	
Data Analytics in Manufacturing: Introduction, Power Consumption in manufacturing, Anomaly Detection in Air Conditioning, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing. Internet of Things and New Value Proposition, Introduction, Internet of Things Examples, IoTs Value Creation Barriers: Standards, Security and Privacy Concerns. Advances in Robotics in the Era of Industry 4.0, Introduction, Recent Technological Components of Robots, Advanced Sensor Technologies, Artificial Intelligence, Internet of Robotic Things, Cloud Robotics.	**08 Hrs**
Unit – IV	
Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies, Stereo lithography, 3DP, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Laser Engineered Net Shaping, Advantages of Additive Manufacturing, Disadvantages of Additive Manufacturing. Advances in Virtual Factory Research and Applications, The State of Art, The Virtual Factory Software , Limitations of the Commercial Software	**07 Hrs**
Unit –V	
Augmented Reality: The Role of Augmented Reality in the Age of Industry 4.0, Introduction, AR Hardware and Software Technology, Industrial Applications of AR, Maintenance , Assembly, Collaborative Operations , Training. Smart Factories: Introduction, Smart factories in action, Importance, Real world smart factories, The way forward. A Roadmap: Digital Transformation, Transforming Operational Processes, Business Models, Increase Operational Efficiency, Develop New Business Models.	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals
CO2	Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services
CO3	Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits
CO4	Evaluate the effectiveness of Cloud Computing in a networked economy

	Reference Books:
1	Alasdair Gilchrist, INDUSTRY 4.0 THE INDUSTRIAL INTERNET OF THINGS, Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7
2	Alp Ustundag, Emre Cevikcan, Industry 4.0: Managing The Digital Transformation, Springer, 2018 ISBN 978-3-319-57869-9.
3	Ovidiu Vermesan and Peer Friess, Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Rivers Publishers, 2016 ISBN 978-87-93379-81-7
4	Christoph Jan Bartodziej, The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler, 2017 ISBN 978-3-6581-6502-4.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
ADVANCED MATERIALS (Group G: Global Elective)						
Course Code	**:**	**18ME2G07**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Classification and Selection of Materials: Classification of materials. Properties required in Engineering materials, Criteria of selection of materials. Requirements / needs of advance materials.	**07 Hrs**
Unit – II	
Non Metallic Materials: Classification of n on metallic materials, Rubber : Properties, processing and applications.Plastics : Thermosetting and Thermoplastics, Applications and properties. Ceramics : Properties and applications. Adhesives: Properties and applications. Optical fibers : Properties and applications. Composites : Properties and applications.	**07 Hrs**
Unit – III	
High Strength Materials: Methods of strengthening of alloys, Materials available for high strength applications, Properties required for high strength materials, Applications of high strength materials	**08 Hrs**
Unit – IV	
Low & High Temperature Materials Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.	**07 Hrs**
Unit –V	
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Describe metallic and non metallic materials
CO2	Explain preparation of high strength Materials
CO3	Integrate knowledge of different types of advanced engineering Materials
CO4	Analyse problem and find appropriate solution for use of materials.

Reference Books:	
1	Donald R. Askeland, and Pradeep P. Fulay, The Science & Engineering of Materials, 5th Edition, Thomson, 2006, ISBN-13-978-0534553968
2	Gregory L. Timp, Nanotechnologym 1999th Editionmm Springer, 1999 ISBN-13: 978-0387983349
3	Dr. VD Kodgire and Dr. S V Kodgire, Material Science and Metallurgym 42nd Edition 2018, Everest Publishing House ISBN NO: 81 86314 00 8
4	N Bhatnagar, T S Srivatsan, Processing and Fabrication of Advanced Materials, 2008, IK International, ISBN: 978819077702

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Common to AS, BT, CH, CV, IM, ME)		
Course Code: 18CHY2G08		**CIE Marks: 100**
Credits: L:T:P :: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**
Course Learning Objectives:		
1	Understand the properties of composite materials.	
2	Apply the basic concepts of Chemistry to develop futuristic composite materials for high-tech applications in the area of Engineering.	
3	Impart knowledge in the different fields of material chemistry so as to apply it to the problems in engineering field.	
4	Develop analytical capabilities of students so that they can characterize, transform and use materials in engineering and apply knowledge gained in solving related engineering problems.	

Unit-I	
Introduction to composite materials Fundamentals of composites – need for composites – Enhancement of properties – Classification based on matrix- Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Constituents of composites, Interfaces and Interphases, Distribution of constituents, Types of Reinforcements, Particle reinforced composites, Fibre reinforced composites. Fiber production techniques for glass, carbon and ceramic fibers Applications of various types of composites.	**07 Hrs**
Unit – II	
Polymer matrix composites (PMC) Polymer resins – Thermosetting resins, Thermoplastic resins & Elastomers, Reinforcement fibres-Types, Rovings, Woven fabrics. PMC processes – Hand Layup Processes, Spray up processes – Compression Moulding – Injection Moulding – Resin Transfer Moulding – Pultrusion – Filament winding – Injection moulding. Glass fibre and carbon fibre reinforced composites (GFRP & CFRP). Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Mechanical Testing of PMC- Tensile Strength, Flexural Strength, ILSS, Impact Strength- As per ASTM Standard. Applications of PMC in aerospace, automotive industries**.**	**08 Hrs**
Unit -III	
Ceramic matrix composites and special composites Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics – need for CMC – ceramic matrix – various types of ceramic matrix composites-oxide ceramics – non oxide ceramics – Aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering – Hot pressing – Cold Isostatic Pressing (CIPing) – Hot isostatic pressing (HIPing). Applications of CMC in aerospace, automotive industries-Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.	**07 Hrs**
Unit –IV	
Metal matrix composites Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties-applications of MMC in aerospace, automotive industries.	**07 Hrs**

Unit –V	
Polymer nano composites Introduction and Significance of polymer Nano composites. Intercalated And Exfoliated Nanocomposites. Classification of Nano fillers- nanolayers, nanotubes, nanoparticles. Preparation of Polymer Nano composites by Solution, In-situ Polymerization and melt mixing techniques. Characterization Of polymer nanocomposites- XRD, TEM, SEM and AFM. Mechanical and Rheological properties of Polymer Nano composites. Gas barrier, Chemical-Resistance, Thermal and Flame retardant properties of polymer nanocomposites. Optical properties and Biodegradability studies of Polymer nanocomposites, Applications of polymer nano-composites.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the purpose and the ways to develop new materials upon proper combination of known materials.
CO2:	Identify the basic constituents of a composite materials and list the choice of materials available
CO3:	Will be capable of comparing/evaluating the relative merits of using alternatives for important engineering and other applications.
CO4:	Get insight to the possibility of replacing the existing macro materials with nano-materials.

Reference Books	
1	Composite Materials Science and Engineering, Krishan K Chawla, 3rd Edition Springer-verlag Gmbh, , ISBN: 9780387743646, 0387743642
2	The Science and Engineering of Materials, K Balani, Donald R Askeland, 6th Edition-Cengage, Publishers, ISBN: 9788131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, ISBN: 9780137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, ISBN: 9781498761666, 1498761666

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Total CIE is 20+50+30=100 Marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester : II		
PHYSICS OF MATERIALS (Group G: Global Elective)		
Course Code: 18PHY2G09		**CIE Marks: 100**
Credits: L:T:P:: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives (CLO):

Student are able to

1.Classify the crystals based on lattice parameters.
2.Explain the behavior of Dielectrics with change in frequency.
3.Classify the magnetic materials based on Quantum theory as well understand superconductors.
4.Explain direct and indirect bandgap semiconductors, polymer semiconductors and Photoconductive polymers.
5.Describe the behavior of Smart materials and its phases and apply to Engineering applications.

Unit-I	**07 Hrs**
Crystal Structure : Symmetry elements-seven crystals systems-Reciprocal lattice-Packing fraction, Lattice Vibration-Brillouin zones, Analysis of Crystal structure using XRD, Thermal properties.	
Unit-II	**07 Hrs**
Dielectric Materials: Basic concepts-Langevin's Theory of Polarisation-Clausius-Mossotti Relation-Ferro electricity-Piezoelectricity-Properties of Dielectric in alternating fields-The complex Dielectric Constant and Dielectric Loss, Polarizability as a function of frequency-Complex dielectric constant of non-polar solids-Dipolar relaxation, Applications.	
Unit -III	**07Hrs**
Magnetic Materials : Dia and Paramagnetic materials-Quantum theory of paramagnetic materials-Paramagnetic susceptibility of conduction electrons-Ferro-anti ferromagnetic materials-Superconductors and Applications..	
Unit -IV	**07 Hrs**
Semiconducting Materials Semiconductor-Direct and Indirect bonding characteristics-Importance of Quantum confinement-quantum wires and dots-Ferro electric semiconductors-applications-Polymer semiconductors-Photo conductive polymers, Applications.	
Unit -V	**08 Hrs**
Novel Materials Smart materials-shape memory alloys-shape memory effects-Martensitia Transformation functional properties-processing-texture and its nature.	

Reference Books:

1.	Solid State Physics, S O Pillai, 6th Edition, New Age International Publishers, ISBN 10-8122436978.
2.	Introduction to Solid State Physics, C.Kittel, 7th Edition, 2003, John Wiley & Sons, ISBN 9971-51-180.
3.	Material Science, Rajendran V and Marikani, 1st Edition, Tata McGraw Hill, ISBN 10-0071328971.
4.	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, 6th Edition, Cengage Learning, ISBN-13:978-0-495-66802-2.

Course Outcomes (CO's):
CO1: Analyse crystals using XRD technique.
CO2: Explain Dielectric and magnetic materials.
CO3:Integrate knowledge of various types of advanced engineering Materials.
CO4: Use materials for novel applications.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
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Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

II Semester		
ADVANCED STATISTICAL METHODS (Global Elective)		
Course Code: 18MAT2G10		**CIE Marks: 100**
Credits: L:T:P:: 3:0:0		**SEE Marks: 100**
Hours: 36		**SEE Duration: 3Hrs**

Course Learning Objectives (CLO):

Students are able to:

1. Adequate exposure to learn sampling techniques, random phenomena for analyzing data for solving real world problems.
2. To learn fundamentals of estimation and problems used in various fields of engineering and science.
3. Explore the fundamental principles of statistical inference and tests of hypothesis.
4. Apply the concepts of regression and statistical models to solve the problems of engineering applications.

Unit-I	07 Hrs

Sampling Techniques:

Random numbers, Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement). Expectation and standard error of sample mean and proportion.

Unit-II	07 Hrs

Estimation:

Point estimation, Estimator and estimate, Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Method of moment's estimation and maximum likelihood estimation, Properties of maximum likelihood estimator (no proofs), Confidence intervals-population mean (large sample), population proportion.

Unit -III	07Hrs

Tests of Hypothesis:

Principles of Statistical Inference, Formulation of the problems with examples, Simple and composite hypothesis, Null and alternative hypothesis, Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Chi squared test for goodness of fit.

Unit -IV	07 Hrs

Linear Statistical Models:

Definition of linear model and types, One way ANOVA and two way ANOVA models-one observation per cell, multiple but equal number of observation per cell.

Unit -V	08 Hrs

Linear Regression:

Simple linear regression, Estimation of parameters, Properties of least square estimators, Estimation of error variance, Multivariate data, Multiple linear regressions, Multiple and partial correlation, Autocorrelation-introduction and plausibility of serial dependence, sources of autocorrelation, Durbin-Watson test for auto correlated variables.

Reference Books:

1	Fundamentals of Statistics (Vol. I and Vol. II), A. M. Goon, M. K. Gupta and B. Dasgupta, 3rd Edition, 1968, World Press Private Limited, ISBN-13: 978-8187567806.
2	Applied Statistics and Probability for Engineers, John Wiley & Sons, Inc., 3rd Edition, 2003,

	ISBN 0-471-20454-4.
3	S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistic, D. C. Montgomery and G. C. Runger, 10th Edition, 2000, A Modern Approach, S Chand Publications, ISBN 81-7014-791-3.
4	Regression Analysis: Concepts and Applications , F. A. Graybill and H. K. Iyer, Belmont, Calif, 1994, Duxbury Press, ISBN-13: 978-0534198695.

Course outcomes (CO's):

On completion of the course, the student should have acquired the ability to

CO1: Identify and interpret the fundamental concepts of sampling techniques, estimates and types, hypothesis, linear statistical models and linear regression arising in various fields engineering.
CO2: Apply the knowledge and skills of simple random sampling, estimation, null and alternative hypotheses, errors, one way ANOVA, linear and multiple linear regressions.
CO3: Analyze the physical problem to establish statistical/mathematical model and use appropriate statistical methods to solve and optimize the solution.
CO4: Distinguish the overall mathematical knowledge gained to demonstrate the problems of sampling techniques, estimation, tests of hypothesis, regression and statistical model arising in many practical situations.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.