RV COLLEGE OF ENGINEERING®

(Autonomous Institution Affiliated to VTU, Belagavi)
RV Vidyaniketan Post, Mysuru Road
Bengaluru – 560059

Scheme and Syllabus of I & II Semester

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)
in
RADIO FREQUENCY AND MICROWAVE ENGINEERING

DEPARTMENT OF

TELECOMMUNICATION ENGINEERING

VISION

Leadership in Quality Technical Education, Interdisciplinary Research & Innovation, with a Focus on Sustainable and Inclusive Technology

MISSION

1. To deliver outcome based Quality education, emphasizing on experiential learning with the state of the art infrastructure.
2. To create a conducive environment for interdisciplinary research and innovation.
3. To develop professionals through holistic education focusing on individual growth, discipline, integrity, ethics and social sensitivity.
4. To nurture industry-institution collaboration leading to competency enhancement and entrepreneurship.
5. To focus on technologies that are sustainable and inclusive, benefiting all sections of the society.

QUALITY POLICY

Achieving Excellence in Technical Education, Research and Consulting through an Outcome Based Curriculum focusing on Continuous Improvement and Innovation by Benchmarking against the Global Best Practices.

CORE VALUES

Professionalism, Commitment, Integrity, Team Work and Innovation

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Master of Technology (M. Tech)

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RADIO FREQUENCY AND MICROWAVE ENGINEERING

DEPARTMENT OF

TELECOMMUNICATION ENGINEERING

DEPARTMENT OF
TELECOMMUNICATION ENGINEERING

VISION

Imparting quality education in electronics and telecommunication engineering through focus on fundamentals, research and innovation for sustainable development.

MISSION

1. Provide comprehensive education that prepares students to contribute effectively to the profession and society in the field of Telecommunication.
2. Create state-of-the–art infrastructure to integrate a culture of research with a focus on Telecommunication Engineering Education.
3. Encourage students to be innovators to meet local and global needs with ethical practice.
4. Create an environment for faculty to carry out research and contribute in their field of specialization, leading to Center of Excellence with focus on affordable innovation.
5. Establish a strong and wide base linkage with industries, R&D organization and academic Institutions.

PROGRAMME OUTCOMES (PO)

M. Tech in Radio Frequency and Microwave Engineering graduates will be able to:

PO1: Acquire in-depth knowledge of RF and Microwave Engineering with an ability to analyze, synthesize, evaluate existing and new technologies.

PO2: Learn and apply modern engineering tools to solve complex engineering problems.

PO3: Engage in life-long learning independently, to contribute for multidisciplinary research work.

PO4: Independently carry out research /investigation and development work to solve practical problems.

PO5: Write and present a substantial technical report/document.

PO6: Demonstrate a degree of mastery over the area Radio Frequency and Microwave Engineering. The mastery would be at a higher than the requirements in the appropriate bachelor program.

ABBREVIATIONS

Sl. No.	Abbreviation	Acronym
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	CE	Professional 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.	PY	Physics
21.	CY	Chemistry
22.	MA	Mathematics
23.	MCA	Master of Computer Applications
24.	MST	Structural Engineering
25.	MHT	Highway Technology
26.	MPD	Product Design & Manufacturing
27.	MCM	Computer Integrated & Manufacturing
28.	MMD	Machine Design
29.	MPE	Power Electronics
30.	MVE	VLSI Design & Embedded Systems
31.	MCS	Communication Systems
32.	MBS	Bio Medical Processing Signal & Instrumentation
33.	MCH	Chemical Engineering
34.	MCE	Computer Science & Engineering
35.	MCN	Computer Network Engineering
36.	MDC	Digital Communication
37.	MRM	Radio Frequency and Microwave Engineering
38.	MSE	Software Engineering
39.	MIT	Information Technology
40.	MBT	Biotechnology
41.	MBI	Bioinformatics

CONTENTS

RV COLLEGE OF ENGINEERING®, BENGALURU - 560059
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DEPARTMENT OF TELECOMMUNICATION ENGINEERING

M. Tech in DIGITAL COMMUNICATION ENGINEERING

FIRST SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1.	18MAT11B	Probability Theory And Linear Algebra	MAT	4	0	0	**4**
2.	18MDC12	Advanced Digital Communication	TE	3	1	1	**5**
3.	18MRM13	RF Circuits-I	TE	3	1	1	**5**
4.	18HSS14	Professional Skills Development*	HSS	0	0	0	**0**
5.	18MRM1AX	Elective -A	TE	3	1	0	**4**
6.	18MRM1BX	Elective - B	TE	4	0	0	**4**
Total number of Credits				**17**	**3**	**2**	**22**
Total Number of Hours/Week				**17**	**6**	**4**	**27**

SECOND SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1.	18MRM21	RF Circuits-II	TE	3	1	1	05
2.	18MRM22	Antenna theory and Design	TE	3	1	0	04
3.	18IEM23	Research Methodology	IEM	3	0	0	03
4.	18MRM24	Minor Project	TE	0	0	2	02
5.	18MRM2CX	Elective-C	TE	4	0	0	04
6.	18MRM2DX	Elective-D	TE	4	0	0	04
7.	18MRM2GX	Global Elective – G	Respective BoS	3	0	0	03
Total number of Credits				**20**	**2**	**3**	**25**
Total Number of Hours/Week				**20**	**4**	**6**	**30**

SEMESTER : I		
GROUP A: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	18MRM1A1	Computational Electromagnetics
2.	18MRM1A2	RF Measurements.
3.	18MDC1A3	Object Oriented Programming
GROUP B: PROFESSIONAL ELECTIVES		
1.	18MRM1B1	EMI & EMC
2.	18MRM1B2	Monolithic Microwave Integrated Circuits Technology
3.	18MDC1B3	Wireless Sensor Networks
SEMESTER : II		
GROUP C: PROFESSIONAL ELECTIVES		
1.	18MRM2C1	Modern Antenna
2.	18MRM2C2	RF Micro Electro Mechanical Systems
3.	18MRM2C3	Tera Hertz Communication systems
GROUP D: PROFESSIONAL ELECTIVES		
1.	18MRM2D1	Optical Communication & Networks
2.	18MRM2D2	**S**atellite Navigation Systems
3.	18MDC2D3	Broad Band Networks

GROUP G: GLOBAL ELECTIVES				
Sl No.	**Course Code**	**Host Dept.**	**Course Title**	**Credits**
1.	18CS2G01	CS	Business Analytics	03
2.	18CV2G02	CV	Industrial & Occupational Health and Safety	03
3.	18IM2G03	IM	Modeling using Linear Programming	03
4.	18IM2G04	IM	Project Management	03
5.	18CH2G05	CH	Energy Management	03
6.	18ME2G06	ME	Industry 4.0	03
7.	18ME2G07	ME	Advanced Materials	03
8.	18CHY2G08	CHY	Composite Materials Science and Engineering	03
9.	18PHY2G09	PHY	Physics of Materials	03
10.	18MAT2G10	MAT	Advanced Statistical Methods	03

SEMESTER : I						
PROBABILITY THEORY AND LINEAR ALGEBRA (Common to MCN, MCE, MCS, MIT, MSE, MRM, MDC)						
Course Code	**:**	**18MAT11B**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**10 Hrs**

Matrices and Vector spaces:

Geometry of system of linear equations, vector spaces and subspaces, linear independence, basis and dimension, four fundamental subspaces, Rank-Nullity theorem(without proof), linear transformations.

Unit – II	**10 Hrs**

Orthogonality and Projections of vectors:

Orthogonal Vectors and subspaces, projections and least squares, orthogonal bases and Gram- Schmidt orthogonalization, Computation of Eigen values and Eigen vectors, diagonalization of a matrix, Singular Value Decomposition.

Unit – III	**11 Hrs**

Random Variables:

Definition of random variables, continuous and discrete random variables, Cumulative distribution Function, probability density and mass functions, properties, Expectation, Moments, Central moments, Characteristic functions.

Unit – IV	**11 Hrs**

Discrete and Continuous Distributions:

Binomial, Poisson, Exponential, Gaussian distributions.

Multiple Random variables:

Joint PMFs and PDFs, Marginal density function, Statistical Independence, Correlation and Covariance functions, Transformation of random variables, Central limit theorem (statement only).

Unit – V	**10 Hrs**

Random Processes:

Introduction, Classification of Random Processes, Stationary and Independence, Auto correlation function and properties, Cross correlation, Cross covariance functions. Markov processes, Calculating transition and state probability in Markov chain.

Course Outcomes

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

CO1	Demonstrate the understanding of fundamentals of matrix theory, probability theory and random process.
CO2	Analyze and solve problems on matrix analysis, probability distributions and joint distributions.
CO3	Apply the properties of auto correlation function, rank, diagonalization of matrix, verify Rank - Nullity theorem and moments.
CO4	Estimate Orthogonality of vector spaces, Cumulative distribution function and characteristic function. Recognize problems which involve these concepts in Engineering applications.

Reference Books

1	Probability, Statistics and Random Processes, T. Veerarajan, 3rd Edition, 2008, Tata McGraw Hill Education Private Limited, ISBN:978-0-07-066925-3.
2	Probability and Random Processes With Applications to Signal Processing and Communications, Scott. L. Miller and Donald. G. Childers, 2nd Edition, 2012, Elsevier Academic Press, ISBN 9780121726515.
3	Linear Algebra and its Applications, Gilbert Strang, 4th Edition, 2006, Cengage Learning, ISBN 97809802327.

4	Schaum's Outline of Linear Algebra, Seymour Lipschutz and Marc Lipson, 5th Edition, 2012, McGraw Hill Education, ISBN-9780071794565.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 : I						
ADVANCED DIGITAL COMMUNICATION (Theory and Practice)						
Course Code	**:**	**18MDC12**		**CIE Marks**	**:**	**100+50**
Credits L:T:P	**:**	**3:1:1**		**SEE Marks**	**:**	**100+50**
Hours	**:**	**39L+26T+26P**		**SEE Duration**	**:**	**3 + 3 Hrs**

Unit – I	**08 Hrs**
Digital Modulation Techniques: Digital modulation formats, Coherent binary modulation techniques, Coherent quadrature – modulation techniques, Non-coherent binary modulation techniques, Comparison of binary and quaternary modulation techniques, M-ray modulation techniques, Power spectra, Bandwidth efficiency.	
Unit – II	**08 Hrs**
Coding Techniques: Convolutional encoding, Convolutional encoder representation, Formulation of the convolutional decoding problem, Properties of convolutional codes: Distance property of convolutional codes, Systematic and nonsystematic convolutional codes, Performance Bounds for Convolutional codes, Coding gain.	
Unit – III	**08 Hrs**
Linear Equalization: Linear equalization, Decision -feedback equalization, Reduced complexity ML detectors.	
Unit – IV	**08 Hrs**
Adaptive Equalization: Adaptive linear equalizer, adaptive decision feedback equalizer, Recursive least square algorithms for adaptive equalization.	
Unit – V	**07 Hrs**
Spread Spectrum Signals for Digital Communication: Model of spread spectrum digital communication system, Direct sequence spread spectrum signals, Frequency hopped spread spectrum signals, CDMA, Time hopping SS.	
Lab Component	**2 Hrs/Week**
The students are expected to design, use modern tools to develop experiments to study the performance and infer changes required in their design for:	
MASK, MFSK, MPSK, QPSK, MSK, GMSK and M-arry modulation techniques. Students are expected to apply Convolution coding,. Linear Equalizers and adaptive equalizers.	
Study the performance of Spread spectrum techniques, multipath diversity and Multicarrier Modulation techniques.	

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

CO1	Explain merits and demerits of different modulation techniques & coding techniques, spread spectrum signals and channel behaviours.
CO2	Analyze various modulation, equalization, diversity and coding techniques for communication systems.
CO3	Compare performance of different types of modulation on different wireless applications.
CO4	Design and demonstrate various modulation/coding equalization techniques and measure their performance.

Reference Books

1.	Digital Communication, Simon Haykin, 2013, Reprint, Wiley, ISBN: 0471647357, 9780471647355.
2.	Digital Communications - Fundamentals and Applications, Bernard Sklar,, 2nd Edition, 2014, Pearson Education (Asia) Pvt. Ltd, ISBN: 1292026065, 9781292026060.
3.	Digital Communications, John G. Proakis, 5th Edition, 2008, McGraw Hill, ISBN 978-0-07-295716-7.
4.	Principles of Digital Communication, Robert G. Gallager, 1st Edition,2008, Cambridge University Press, ISBN-13: 978-0521879071.

Scheme of Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Scheme of Continuous Internal Evaluation (CIE): Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) is 20+50+30=100 Marks.

Continuous Internal Evaluation (CIE): Practical (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) 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 (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): Total marks: 100+50=150

Theory (100 Marks) + Practical (50 Marks) =Total Marks (150)

SEMESTER : I						
RF CIRCUITS I (Theory and Practice)						
Course Code	**:**	**18MRM13**		**CIE Marks**	**:**	**100+50**
Credits L:T:P	**:**	**3:1:1**		**SEE Marks**	**:**	**100+50**
Hours	**:**	**39L+26T+26P**		**SEE Duration**	**:**	**3 + 3 Hrs**

Unit – I	**08Hrs**
Introduction: Radio frequency and Microwave circuit applications, Radio frequency waves, RF and Microwave circuit design considerations, Introduction to component basics, Microstrip line, Formulation and properties of S-parameters, Smith chart Concepts, Types.	
Unit – II	**08Hrs**
Applications of Smith chart: Distributed circuits- Transmission lines, Microstrip lines, Lumped element circuits- RC, RL.	
Unit – III	**08Hrs**
Impedance Matching networks: Goal of impedance matching, Components for matching, Design of Matching Networks - Matching network design using Lumped elements- RC, RL circuits, Design of Matching Networks using Distributed Elements- Transmission lines, Microstrip lines, Stubs.	
Unit – IV	**08Hrs**
Couplers and Power dividers - Basic properties, Types, Power combining efficiency, Wilkinson Power divider-equal and unequal types, 90° Hybrids, Branch line couplers, N-way combiners, Corporate structures, Spatial combining, **Phase shifters -** Types, Transmission line type, Reflection types phase shifters**.**	
Unit – V	**07Hrs**
RF Resonators and Filters - Basic Resonator types, transmission line resonators, Resonant waveguide cavities, Excitation of resonators. **RF Filters**: Basic filter configurations, Special Filter Realizations, Filter Implementation, Coupled Filter.	

Lab Component
The students are expected to design, use modern tools to develop experiments to study the performance and infer changes required in their design for:
The students are expected to design, use modern tools to develop experiments to study the performance and infer changes required in their design for:
S-parameters, VSWR, power measurements of waveguide components using microwave benches.
Radiation pattern, gain and directivity measurements of parabolic and horn antenna using microwave benches.
Design and characterization of Microstrip lines using line-calc tool.
Lumped and distributed matching circuits design using smith chart tools.

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

CO1	Review the concepts of RF components and circuits, smith charts, RF subsystems.
CO2	Analyze the performance parameters of RF passive components.
CO3	Design RF passive circuit for communication applications.
CO4	Evaluate the performance of RF passive circuits using EDA tools

Reference Books

1.	RF and Microwave Electronics Illustrated, Matthew M. Radmanesh, 1st edition, 2004, Pearson Education, ISBN-978-81-775-8401-1
2.	RF Circuit Design Theory and Applications, Reinhold Ludwig, and Pavel Bretchko, 2004, Pearson Education edition, ISBN: 978-81-317-6218-9.
3.	Microwave Engineering, D. Pozar, 2005, John Wiley & Sons, New York.: ISBN: 978-0-470-63155-3.
4.	Microwave Solid State Circuit Design, Inder Bahl and Prakash Bhartia, , 2nd edition, Wiley India edition, ISBN: 978-0471207559.

Scheme of Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Scheme of Continuous Internal Evaluation (CIE): Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) is 20+50+30=100 Marks

Continuous Internal Evaluation (CIE): Practical (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) 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 (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): Total marks: 100+50=150

Theory (100 Marks) + Practical (50 Marks) =Total Marks (150)

SEMESTER : I
PROFESSIONAL SKILL DEVELOPMENT
(Common to all Programs)

Course Code	**:**	**18HSS14**	**CIE Marks**	**:**	**50**
Credits L: T: P	**:**	**0:0:0**	**SEE Marks**	**:**	**Audit Course**
Hours	**:**	**24 L**			

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 **03 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

Phase	Activity
I	After the completion of Unit 1 and Unit 2, 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	Students will have to take up second test after the completion Unit 3, Unit 4 and Unit 5. 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%. The attendance will be same as other courses.

SEMESTER : I						
COMPUTATIONAL ELECTROMAGNETICS (Professional Elective-A1)						
Course Code	**:**	**18MRM1A1**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**03 Hrs**
Unit – I						**07 Hrs**
Fundamental concepts: Electrostatic Fields, Magneto static fields, Maxwell's Equations, boundary conditions, wave equations, time varying potentials, Classification of EM problems- classification of Solution regions, differential equations, and boundary conditions, superposition principle and uniqueness theorem.						
Unit – II						**08 Hrs**
Analytical Methods: Introduction, Separation of variables, separation of variables in rectangular coordinates – Laplace and wave equation, separation of variables in cylindrical coordinates – Laplace and wave equation..						
Unit – III						**08 Hrs**
Green's Functions: Green's function technique for the solution of partial differential equations, classification of Green's functions, various methods for the determination of Green's functions including Fourier transform technique and Ohm-Rayleigh technique, dyadic Green's functions, determination of Green's functions for free space, transmission lines, waveguides, and micro-strips.						
Unit – IV						**08 Hrs**
Integral Equations: Formulation of typical problems in terms of integral equations: wire antennas, scattering, apertures in conducting screens and waveguides, discontinuities in waveguides and micro striplines; Solution of Integral equations: General Method of Moments (MoM) for the solution of integro-differential equations, choice of expansion and weighting functions, application of MoM to typical electromagnetic problems. **Finite Element Method:** Introduction, Solution of Laplace equation, Solution of Poisson's equation, Solutions of Wave equation.						
Unit – V						**08 Hrs**
FDTD: Finite Difference Schemes, Finite differencing of Parabolic PDE, Hyperbolic PDE, Elliptic PDEs, Yee's Finite Differencing, Accuracy and Stability, Programming Aspects.						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Explain the fundamental principles of electromagnetics, merits and demerits of CEM techniques.					
CO2	Compute electric field and magnetic field for simple linear structure using analytical and computational techniques.					
CO3	Apply residual calculus in deriving and analyzing various computational techniques					
CO4	Classify and Prioritize different CEM techniques based on the applications					
Reference Books						
1.	Numerical Techniques in Electromagnetics, Sadiku, M.N.O, 2nd Edition, 2001, CRC Press, ISBN: 0-8493-1395-3.					
2.	Computational Methods for Electromagnetics, Peterson, A.F, Ray, S.L. and Mittra, R,1998, Wiley-IEEE Press, ISBN: 81-7371-377-4.					
3.	Field Computation by Moment Methods, Harrington, R.F., 1993, Wiley-IEEE Press, ISBN: 0-7803-1014-4.					
4.	Finite Method for Electromagnetics, Volakis, J.L, Chatterjee, A. and Kempel, L.C., 1998, Wiley-IEEE Press., ISBN: 81-7371-389-8.					

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 : I						
RF MEASUREMENTS (Professional Elective-A2)						
Course Code	**:**	**18MRM1A2**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**03 Hrs**

Unit – I — **08 Hrs**

Applications and Importance of Microwave Measurements, Overview of State-of-the-Art Microwave Measurements, S-Parameters and Related Black-Box Representation, Spectra of Commonly Encountered Signals, Microwave Filters and Directional Couplers, Microwave attenuators, Connectors and adapters.
Traditional Measurement Techniques-The Power Meter-Thermocouple –based Power detector, transmission Measurement, Reflection Measurement.

Unit – II — **08 Hrs**

Vector Network Analyzer-Enhancement of Scalar Measurement, Basic Vector Measurements, Architecture of the Vector Network Analyzer, Network Analyzer Calibration –One Port and Two port(without Mathematical Derivation)
Frequency Offset and Mixer Measurement, Time Gating, Nonlinear Measurements and X-Parameters.

Unit – III — **08 Hrs**

Spectrum Analyzer- Common Measurements Using the Spectrum Analyzer, Types of Signal Analyzers, Basic Idea Behind Spectrum Analyzers, Building Blocks of a Spectrum Analyzer, Features of the Spectrum Analyzer, Extending the Frequency Range, Dynamic Range and Sensitivity, Component Characterization.

Unit – IV — **08 Hrs**

Noise Measurements-Definition, Noise Measurement Basics, Special Consideration for Mixers, Phase Noise, Phase Noise Measurement Techniques,
Microwave Signal Generation-Oscillator Circuits, Crystal Oscillator, Tunable Oscillator, Direct Digital Synthesis (DDS), PLL-Based Synthesizers, Requirement for microwave oscilloscopes, Block diagram, Probes-Active and Passive.

Unit – V — **07 Hrs**

Antenna and RF systems Measurements: Reciprocity and Antenna measurements, Pattern measurements and Ranges, Gain measurements, Polarization measurements, Field Intensity Measurements, Application examples.

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

CO1	Identify traditional measurement Techniques for RF circuits and systems
CO2	Analyze the working principle of measuring components and systems.
CO3	Analyze the Various measurement setups for parameters of RF active systems.
CO4	Demonstrate the Antenna and RF systems measurement setups.

Reference Books

1.	Introduction to Microwave Measurements, Ananjan Basu,2014, CRC Press, ISBN :978-1-4822-1436-9.
2.	Antenna Theory and Design, Stutzman and Thiele, 2nd Edition, 2013, John Wiley and Sons Inc. ISBN :978-81-265-2377-1.
3.	Antenna Theory Analysis and Design, C. A. Balanis, 2nd Edition, 2004., John Wiley, ISBN: 9780471592686.
4.	Practical Radio frequency Test and Measurements: A Technician's Handbook. Joseph Carr,British Library, ISBN-13:978-0-7506-7161-3.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 : I						
OBJECT ORIENTED PROGRAMMING CONCEPTS (Professional Elective-A3)						
Course Code	**:**	**18MDC1A3**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**03 Hrs**

Unit – I	**08 Hrs**
Overview of C++: Principles of object-objective Programming, Tokens, Expressions and control structures, Functions in C++, Classes and Objects, Destructors and Constructors.	
Unit – II	**08 Hrs**
Concepts of Object Oriented Programming: Operator Overloading, Inheritance: Extending Classes, Pointers, Virtual functions and polymorphism, Exception handling, Class Templates.	
Unit – III	**08 Hrs**
Data Structures - Lists: Linear lists, Linked list, Matrices - Special Matrices and Sparse Matrices.	
Unit – IV	**08Hrs**
Data Structures - Stacks, Queues: Stacks using Linear, Link List , Applications - Towers of Hanoi, Switch Box Routing Queues using Linear, Link List , Applications - Rail Road Car Arrangement, Image Component Labeling.	
Unit – V	**07Hrs**
Data Structures -Trees, Graphs: Hash Tables, Binary Trees and Graphs (Representation, Class Definitions).	

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

CO1	Exhibit program design and implementation competence through the choice of appropriate object oriented concept and data structures.
CO2	Design and analyze the applications using Object Oriented Approach and data structures.
CO3	Envision the solutions for real-time problems using Object Oriented concepts and data structures.
CO4	Implement data Structures using C++.

Reference Books:

1.	Object Oriented Programming with C++, E. Balaguruswamy, 4th edition, 2012, McGraw Hill,Company Ltd.,ISBN: 0070593620.
2.	Data Structures, Algorithms, and Applications in C++, Sartaj Sahni, 2000, McGraw Hill, ISBN: 0-929306-33-3.
3.	Big C++, Cay S. Horstmann, Timothy Budd, Wiley India (P.) Ltd, 1st Edition, 2009, ISBN: 9788126509201.
4.	The Complete Reference C++, Herbert Schildt, McGrawHill, 4th Edition, 2011, ISBN: 9780070532465.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) 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 : I						
EMI and EMC (Professional Elective-B1)						
Course Code	**:**	**18MRM1B1**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**

Unit – I	**10Hrs**
EMC Requirements for Electronic Systems: Sources of EMI; Aspects of EMC; Radiated susceptibility, Conducted susceptibility, Electrostatic discharge; Design constraints for products, Advantages of EMC design; **Transmission line and Signal Integrity:** Transmission line per-unit-length parameters: Wiretype structures, PCB structures; High-speed digital interconnects and signal integrity.	
Unit – II	**10Hrs**
Conducted and Radiated Emissions: Measurement of conducted emissions; Power supply filters; Power supply and its placement; Conducted susceptibility; Simple emission models for wires and PCB leads; Simple radiated susceptibility models for wires and PCB leads; High Frequencies and Undesired Radiation, Electromagnetic Compatibility Design..	
Unit – III	**10Hrs**
Conducted and Radiated Emissions: Measurement of conducted emissions; Power supply filters; Power supply and its placement; Conducted susceptibility; Simple emission models for wires and PCB leads; Simple radiated susceptibility models for wires and PCB leads; High Frequencies and Undesired Radiation, Electromagnetic Compatibility Design.	
Unit – IV	**12Hrs**
Crosstalk: Three-conductor transmission lines, shielded wires, twisted wires, shielding. **System Design for EMC:** Safety ground; PCB design; System configuration and design. Bypassing and decoupling **Microstrip:** Discontinuities, vias and slots, bends, tee- junction; Vias, Via Fences and Grunding Pads, Multilayer printed circuit boards.	
Unit – V	**10Hrs**
EMI standards and measurements: Open area test site; TEM cell; EMI test shielded chamber and shielded ferrite lined anechoic chamber; Tx /Rx Antennas, Sensors, Injectors / Couplers, and coupling factors; EMI Rx and spectrum analyzer; Civilian standards-CISPR, FCC, IEC, EN; Military standardsMIL461E/462.	

Course Outcomes

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

CO1	Understand and explain the concepts of EMI and EMC, standards and measurements.
CO2	Apply EMI controlling techniques to reduce effect of interference on modern communication systems.
CO3	Analyze and measure the system for EMI and EMC to the standards defined.
CO4	Design and develop a system and PCBs to control the effects of electromagnetic interference.

Reference Books:

1.	Introduction to Electromagnetic Compatibility, C.R.Paul, 2008, John Wiley and Sons, Inc., ISBN: 978-0-471-75500-5.
2.	Engineering EMC Principles, Measurements and Technologies, V.P.Kodali,2010, IEEE Press, Newyork, ISBN:0-7803-1117-5.
3.	Introduction to RF Design Using EM Simulators, Hiroaki Kogure, Yoshie Kogure, James C. Rautio, Artech house, 978-1-60807-155-5.
4.	Printed circuit broad design techniques for EMC compliance, Mark I. Montrose, 2nd Edition, 2000, IEEE press, ISBN 0-7803-5376-5.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 : I						
MONOLITHIC MICROWAVE INTEGRATED CIRCUITS TECHNOLOGY (Professional Elective-B2)						
Course Code	**:**	**18MRM1B2**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Introduction: Brief History, Advantages and disadvantages of MMICs, Applications, Active device Technology, Design Approaches, Multi-chip module Technology. **Devices and fabrication technology**: Substrate and Technologies, Passive lumped elements, BJTs,FETs, Comparison of BJTs and FETs.						
Unit – II						**10Hrs**
Passive Components: Inductors, Capacitors, Resistors, via-holes and Grounding, Micro strip and Co-planar components, Multi layer Techniques, Micro mechanical Passive components.						
Unit – III						**10Hrs**
CAD Techniques: Integrated CAD Design Environment, CAD package features, Circuit simulation Engines, Commercial CAD packages, Commercial Modeling Software. EM simulation Tools.						
Unit – IV						**12Hrs**
Transceivers: Conventional UP/Down conversion architectures, Direct Conversion architectures, Modulators, demodulators and Frequency Translators. **Integrated Antennas**: Basic Integrated Antenna Requirements, Integrated Antenna selection and examples, Photonic Band gap antennas.						
Unit – V						**10Hrs**
Monolithic amplifiers: Monolithic IC technology, MMIC design and examples, CMOS fabrication. **Amplifier packages:** Amplifier packaging overview, materials for packages, ceramic package design, and plastic package design, package assembly, thermal considerations, CAD Tools for packages, power amplifier modules.						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Understand the basics of MMIC design, components, devices and packaging					
CO2	Apply CAD and fabrication Techniques in designing MMIC circuits					
CO3	Analyze the design challenges of passive and active MMIC Circuits					
CO4	Evaluate the performance of MMIC designs using CAD tools.					
Reference Books						
1.	RFIC and MMIC design Technology, I. D. Robertson, S. Lucyszyn, , 2001, IEEE Publications, ISBN: 0-85296- 786 -1.					
2.	Fundamentals of RF and Microwave Transistor Amplifiers, Inder J Bahl, 2009, John Wiley & sons Inc,. ISBN: 978-0-470-39166-2.					
3.	VLSI Fabrication principles – Silicon and Gallium Arsenide, Sorab. K. Ghandhi, 2nd Edition, 2009, Wiley India, ISBN: 978-81-265-1790-9.					
4.	RF and Microwave Electronics Illustrated, Matthew M. Radmanesh, 1st edition, 2004, Pearson Education, ISBN-978-81-775-8401-1.					

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 : I						
WIRELESS SENSOR NETWORKS (Professional Elective-B3)						
Course Code	**:**	**18MDC1B3**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Introduction, Overview and Applications of Wireless Sensor Networks Introduction: Background of Sensor Network Technology, Basic overview of the Technology: Basic Sensor Network Architectural Elements, Applications of Wireless Sensor Networks: Introduction, Background, Range of Applications, Examples of Category 2 WSN Applications, Examples of Category 1 WSN Applications, Another Taxonomy of WSN Technology.						
Unit – II						**10Hrs**
Basic Wireless Sensor Technology: Introduction, Sensor Node Technology, Sensor Taxonomy, WN Operating Environment, WN Trends. **MAC and Routing Protocols for Wireless Sensor Networks:** Introduction, Background, Fundamentals of MAC Protocols, MAC Protocols for WSNs, Sensor-MAC case Study, IEEE 802.15.4 LR-WPANs Standard Case Study.						
Unit – III						**10Hrs**
Routing Protocols for Wireless Sensor Networks: Introduction, Background, Data Dissemination and Gathering, Routing Challenges and Design Issues in WSNs, Routing Strategies in WSNs.						
Unit – IV						**12Hrs**
Transport Control and Middleware for Wireless Sensor Networks : Traditional Transport Control Protocols, Transport Protocol Design Issues, Examples of Existing Transport Control Protocols, Performance of Transport Control Protocols..						
Unit – V						**10Hrs**
Middleware for Wireless Sensor Networks: Introduction, WSN Middleware Principles, Middleware Architecture, Existing Middleware: MiLAN (Middleware Linking Applications and Networks), IrisNet (Internet-Scale Resource-Intensive Sensor Networks Services).						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Describe the type of sensor networks, protocols and applications of WSN.					
CO2	Analyze the design issues of Transport, Network, MAC and Physical layers of WSN.					
CO3	Create architecture and Identify need and selection of protocols for WSN.					
CO4	Explore various middleware and transport protocols that exist for sensor networks.					
Reference Books						
1.	Wireless Sensor Networks: Technology, Protocols and Applications, Kazem Sohraby, Daniel Minoli, Taieb Znati, 2nd Edition (Indian), 2014, WILEY, ISBN 978-0-471-74300-2.					
2.	Wireless Sensor Networks, Ian F. Akyildiz, Mehmet Can Vuran,2010,Wiley, ISBN-13: 978-0470036013.					
3.	Wireless SensorNetworks- An Information Processing Approach, Feng Zhao & Leonidas J. Guibas, 2007, Elsevier, ISBN-1558609148, 9781558609143.					
4.	Fundamentals of Wireless Sensor Networks Theory and Practice, Waltenegus Dargie and Christin Poellabauer, 1st EditionJohn Wiley 2010, ISBN 978-0-470-99765-9.					

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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						
RF Circuits –II (Theory and Practice)						
Course Code	**:**	**18MRM21**		**CIE Marks**	**:**	**100+50**
Credits L:T:P	**:**	**3:1:1**		**SEE Marks**	**:**	**100+50**
Hours	**:**	**39L+26T+26P**		**SEE Duration**	**:**	**3+3Hrs**
Unit – I						**07Hrs**
Active RF Components: RF diodes - Schottky diode, PIN diode, Varactor diode and Gunn diode, Bipolar junction transistor - construction, functionality, frequency response, temperature behavior, limiting values, noise performance, RF field effect transistors, metal oxide semiconductor transistors, High electron mobility transistors, semiconductor technology trends. Introduction to transceiver architecture.						
Unit – II						**08Hrs**
Microwave Amplifier-I: Amplifier classes of operation and biasing networks, characteristic of amplifiers, amplifier power relations, stability considerations, and constant gain.						
Unit – III						**08Hrs**
Microwave Amplifier-II: Noise figure circles, constant VSWR circles, Broadband amplifiers, High power amplifiers, Multistage amplifiers, Low noise amplifiers.						
Unit – IV						**08Hrs**
Oscillators: Basic oscillator models - Feedback oscillator, Negative Resistance oscillator, oscillator phase noise, feedback oscillator design, design steps, quartz oscillators, High frequency oscillator configuration- fixed frequency oscillator, Dielectric Resonator oscillators, Voltage controlled oscillator, Gunn element oscillator.						
Unit – V						**08Hrs**
Mixers: Basic consideration of Mixers- basic concepts, frequency domain considerations, single ended mixer design, single balanced mixer, double balanced mixers, Integrated active mixers and image reject mixer. Introduction to Frequency synthesizer.						
Lab Component						
The students are expected to design, use modern tools to develop experiments to study the performance and infer changes required in their design for:						
Design and characterization of Micro strip antenna using HFSS/EMPro tools						
Design of biasing network, matching network, stability, Noise figure for a given BJT/FET using ADS						
Design and characterization of linear amplifier, oscillator and Mixer using ADS.						
Demonstration of network analyzer, spectrum analyzer and VSA for RF Testing and measurements.						
Course Outcomes **After successful completion of this course the student will be able to**						
CO1	Review and Describe Active RF components, semiconductor devices, Active circuits.					
CO2	Model and analyze performance RF devices and circuits					
CO3	Design RF active circuits for given specifications					
CO4	Evaluate the Performance of RF active circuits through EDA tools.					
Reference Books						
1.	RF circuit design, theory and applications, Reinhold Ludwig, Pavel Bretchko, 2nd Edition, 2012, Pearson Asia Education, ISBN: 978-81-317-6218-9.					
2.	Fundamentals of RF and Microwave Transistor Amplifiers, Inder J Bahl, 2009, John Wiley & Sons Inc, ISBN: 9780470391662.					
3.	RF and Microwave Electronics Illustrated, Matthew M. Radmanesh, 1st edition, 2004, Pearson Education, ISBN-978-81-775-8401-1.					
4.	Microwave Engineering, D. Pozar, 2005, John Wiley & Sons, New York.: ISBN: 978-0-470-63155-3..					

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) is 20+50+30=100 Marks

Scheme of Continuous Internal Evaluation (CIE); Practical (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) 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 (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): Total marks: 100+50=150

SEMESTER : II						
ANTENNA THEORY AND DESIGN (Theory)						
Course Code	**:**	**18MRM22**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**03Hrs**

Unit – I	**07Hrs**
Introduction: Antenna Radiation mechanism, Fundamental Concepts of antenna parameters. **Dipoles and Loops:** Radiation from Wires and Loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.	
Unit – II	**08Hrs**
Arrays: Two Element Array, N-Element Linear Array - Uniform Amplitude and Spacing, Directivity, Non Uniform Amplitude Array Factor: Binomial Array, Dolph -Tschebyscheff Array, Planar Array.	
Unit – III	**08Hrs**
Broad Band Antennas: Helical Antennas, Design Concepts, Frequency Independent Antennas - Equiangular Spiral Antennas, Log Periodic Antennas, Design Concepts. **Microstrip Antennas:** Basic Characteristics, Feeding Methods, Rectangular Patch Transmission Line Model, Design Concepts.	
Unit – IV	**08Hrs**
Aperture Antennas: Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, **Horn and Reflector Antennas:** Radiation from sectoral and pyramidal horns, design concepts, Radiation from parabolic reflector and cassegrain antennas.	
Unit – V	**08Hrs**
Antenna Synthesis: Synthesis of antenna arrays using Fourier transform method, Woodward-Lawson method. **Method of Moments**-Solution to Pocklington Integral Equation, MOM Method, Basis Function and Sources.	

Course Outcomes

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

CO1	Elucidate the basic principles of radiation for various antennas and antenna parameters.
CO2	Analyze the characteristics of various Antennas and solve radiation problem using MOM method.
CO3	Design or synthesize various antennas.
CO4	Compute, compare and simulate various Antennas.

Reference Books

1.	Antenna Theory Analysis and Design, C. A. Balanis. 2nd Edition, 2004, John Wiley, ISBN-9780471592686.
2.	Antenna Theory and Design, Stutzman and Thiele, 2nd Edition, 2013, John Wiley and Sons Inc., ISBN- 978-0-470-57664-9.
3.	Antennas and Wave Propagation, John D Kraus, Ronald J Marhefka and Ahmad S Khan, 4th Edition 2010, Tata McGraw Hill, ISBN- 987-0-07-067155-3.
4.	Modern Antenna Design, THOMAS A. MILLIGAN, 2nd Edition 2005, John Wiley and Sons Inc. , ISBN-978-0-471-45776-3.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) 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	**:**	**18IEM23**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**07Hrs**
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.						
Unit – II						**08Hrs**
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..						
Unit – III						**08Hrs**
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.						
Unit – IV						**08Hrs**
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.						
Unit – V						**08Hrs**
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.						
Course Outcomes **After successful completion of 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.	Research Methodology Methods and techniques, Kothari C.R., 4th edition, New Age International Publishers, ISBN: 978-93-86649-22-5.					
2.	Management Research Methodology, Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, 2006, M., Pearson Education: New Delhi, ISBN: 978-81-77585-63-6.					
3.	The Research Methods Knowledge Base, William M. K. Trochim, James P. Donnelly, 3rd Edition, Atomic Dog Publishing, 2006. ISBN: 978-1592602919					
4.	Statistics for Management, Levin, R.I. and Rubin, D.S., 7th Edition, Pearson Education: New Delhi, ISBN-10: 8131774503.					

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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					
Course Code	**:**	**18MRM24**	**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**0:0:2**	**SEE Marks**	**:**	**100**
Hours	**:**	**4**	**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%

SEMESTER : II						
MODERN ANTENNAS (Professional Elective-C1)						
Course Code	**:**	**18MRM2C1**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Introduction to Smart Antennas: Need for Smart Antennas, Overview, Smart Antenna Configurations, Space Division Multiple Access, Architecture of Smart Antenna System, Benefits, Drawbacks, Basic Principles, Mutual Coupling Effects.						
Unit – II						**10Hrs**
Beamforming: Fixed Weight Beamforming Basics - Maximum Signal-to-Interference Ratio, Minimum Mean-Square Error, Maximum Likelihood, Minimum Variance Adaptive Beamforming - Least Mean Squares, Sample Matrix Inversion, Recursive Least Squares Constant Modulus, Least Squares Constant Modulus, Conjugate Gradient Method, Spreading Sequence Array Weights, Description of the New SDMA Receiver.						
Unit – III						**10Hrs**
Angle-of-Arrival Estimation: Array Correlation Matrix, AOA Estimation Methods -Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, Root-MUSIC AOA Estimate, ESPRIT AOA Estimate.						
Unit – IV						**12Hrs**
Metamaterial Antennas: Introduction , Negative Refractive Index (NRI) Metamaterials , Metamaterial Antennas Based on NRI Concepts ,High-Gain Antennas Utilizing EBG Defect Modes, Antenna Miniaturization Using Dispersion Properties of Layered Anisotropic Media, Wideband Metamaterial Antenna Arrays.						
Unit – V						**10Hrs**
Reconfigurable Antennas: Introduction, Analysis, Overview of Reconfiguration Mechanisms for Antennas, Control, Automation, and Applications.						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Elucidate parameters and principles of Adaptive Antennas, Metamaterial Antennas and Reconfigurable Antennas.					
CO2	Apply signal processing concepts in analyzing beamforming techniques.					
CO3	Analyze and Compare various techniques employed in designing Adaptive Antennas, Metamaterial Antennas and Reconfigurable Antennas					
CO4	Compute design parameters of Adaptive Antennas, Metamaterial Antennas and Reconfigurable Antennas.					
Reference Books						
1.	Smart Antennas with Matlab: Principles and Applications in Wireless Communication, Frank B Gross,2015, McGraw-Hill Professional, New York, ISBN- 978-0-07-182494-1.					
2.	Frontiers in Antennas: Next Generation Design & Engineering, Frank B gross, 2011, Mcgraw Hill Publications, ISBN : 9780071637930.					
3.	Introduction to Smart Antennas. Synth. Lect. Antennas, Balanis, C.A., Ioannides, P.I.: 2(1), 1–175,2007, 9781598291766.					
4.	Smart antenna, Lal Chand Godara, 2004, CRC press, London, ISBN: 9780849312069.					

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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						
RF MICRO ELECTRO MECHANICAL SYSTEMS (Professional Elective-C2)						
Course Code	**:**	**18MRM2C2**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Introduction: RF MEMS for microwave applications, Micro fabrication for MEMS, Materials for MEMS, MEMS materials and fabrication techniques.						
Unit – II						**10Hrs**
MEMS Switches: Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modeling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches.						
Unit – III						**10Hrs**
Inductors and Capacitors: Micromachined passive elements; Micromachined inductors: Effect of inductor layout, reduction of stray capacitance of planar inductors, folded inductors, variable inductors and polymer-based inductors; MEMS Capacitors: Gap-tuning and area-tuning capacitors, dielectric tunable capacitors.						
Unit – IV						**12Hrs**
Phase Shifters: RF Filters, Micromachined Antennas: Reflection-Type Phase Shifters, Switched-Line Phase Shifters, Loaded-Line Phase Shifters, Analysis of Distributed Mems T Lines, The DMTL Implementation, Phase Shift Of The DMTL, Surface acoustic wave filters, Micromachined antennas: Micromachining techniques to improve antenna performance, reconfigurable antennas..						
Unit – V						**10Hrs**
Integration and Packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues.						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Identify various RF for MEMS devices, fabrication techniques and packaging standards.					
CO2	Model MEMS filters and Phase shifters for specific RF applications.					
CO3	Analyze the reliability and design issues in MEMS structures.					
CO4	Design micro machined passive components such as Inductors, Capacitors, Switches and Antennas.					
Reference Books						
1.	RF MEMS and their Applications, Vijay K Varadan , K J Vinoy and K A Jose,2002, John Wiley & Sons, ISBN 0-470-84308-X.					
2.	MEMS: Theory Design and Technology, Rebeiz G M, 1999,John Wiley & Sons, ISBN 0-461-20169-3.					
3.	RF MEMS Circuit Design for Wireless Communications, De Los Santos H J,1999, Artech House, ISBN 1-58053-329-9.					
4.	RF Technologies for low power Wireless Communications, Tatsuo Itoh, George Haddad, James Harvey,A John Wiley & Sons Publications, ISBN 0-471-38267-1.					

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.
Total CIE (Q+T+A) 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.

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						
TERAHERTZ COMMUNICATION (Professional Elective-C3)						
Course Code	**:**	**18MRM2C3**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**

Unit – I	**10Hrs**
Terahertz Overview and Principles: Electromagnetic Radiation and Propagation Fundamentals, Terahertz Principles, Towards Terahertz communication systems, Key technological issues for Terahertz technology, Fundamental limits, Terahertz technology Applications and opportunities**.**	
Unit – II	**10Hrs**
Terahertz Sources : The development of Terahertz sources, Terahertz sources based on Schottky diode frequency multipliers, Free Electron based Tera Hertz sources, Compact Tunable Terahertz Sources very short wave length Vacuum Electronic devices, Photo mixing Tunable Terahertz sources, Terahertz magnetic response from artificial material, Continuous wave THz radiation generation through non linear processes.	
Unit – III	**10Hrs**
THz Detectors: Pyroelecrtic detectors, gallium doped Germanium photoconductive detector, Bolometer detectors, composite Germanium Bolometer, unturned Indium Antimode, Go lay Cell detectors, Terahertz Electronic components, Travelling Wave Terahertz detector, Tunable Plasma Wave-HEMT THz Detector, Terahertz detector on a single chip, Quantum dot Photo detector, Multiband Terahertz detection and imaging devices, Integrated Terahertz Imager based on quantum dots, CNT based QD frequency tunable THz detector.	
Unit – IV	**12Hrs**
Low coherence THz signal sources and applications and THz chemical spectroscopy: Introduction, Schemes for Noise generation, Characterization of noise signals,Imaging,2D imaging, Tomographic imaging, spectroscopy, amplifier characterization,THZ TDS overview, Application: Terahertz spectroscopic imaging, overview, measurement system, Application(1):chemical mapping of pharmaceuticals in medicine, Application (2):chemical mapping of pharmaceuticals cocrystals.	
Unit – V	**10Hrs**
Industrial and Wireless communications Applications of Terahertz waves : Different kinds of Terahertz systems, Polymer Industry, Polymeric compounds, Paper Industry, Food Industry, Pharmaceuticals Industry, crops Industry, why the terahertz waves for communication, Application scene of terahertz communication, current technologies, frequency dispersion, Ray shadowing by moving persons.	

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

CO1	Identify THz principles and components.
CO2	Select THz sources and detectors for a given for different applications.
CO3	Analyze suitability of THz imaging and spectroscopy systems for different applications.
CO4	Apply THZ systems knowledge for different Industrial and communication applications.

Reference Books

1.	Terahertz Technology: Fundamentals and applications, Rostami, Ali Rasooli, Hassan Baghban, New York, Springer, 2011, *ISBN* 978-3-642-15793-6.
2.	RE Miles,P Harisson, D Lippens "Terahertz Sources and Systems ",Springer Science+Business media, BV 2000, *ISBN* 978-94-010-0824-2.
3.	Kiyomi Sakai, "Terahertz Optoelectronics", Springer, 2004, *ISBN* 978-3-540-20013-0.
4.	Ho-Jin Song,Tadao Nagatsuma, "Handbook of Terahertz Technologies, Devices and applications", Pan Stanford Publishing Pte. Ltd. 2015, *ISBN*: 9789814613088.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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						
OPTICAL COMMUNICATION AND NETWORKS (Professional Elective-D1)						
Course Code	**:**	**18MRM2D1**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Introduction Introduction to optical fibers, Propagation of signals in optical fiber, Different losses, Effective Length & Area, Stimulated Brillouin Scattering, Stimulated Raman Scattering, Solitons, Propagation in a Non linear medium, Self phase modulation, SPM – induced Chirp for Gaussian pulses, Cross phase Modulation, Optical sources, Detectors.						
Unit – II						**10Hrs**
Optical Components: Couplers, Isolators, Circulators, Multiplexers, filters, Gratings, Interferometers, Amplifiers. **Modulation & Demodulation:** Sequential Decoding and Feedback Decoding, Formats, Ideal Receivers, Practical detection receivers, Optical preamplifier, Noise Considerations, Bit error rates, Coherent detection, Timing Recovery.						
Unit – III						**10Hrs**
Transmission System Engineering: System model, Power penalty, Transmitter, Receiver, Different Optical Amplifiers, Dispersion. **Optical networks:** Client layers of the optical layer, SONET/SDH, Multiplexing, layers, Frame Structure, ATM functions, Adaptation layers, Quality of service and flow, ESCON, HIPPI.						
Unit – IV						**12Hrs**
WDM network elements: Optical line terminal, Optical line amplifiers, Optical cross connectors, WDM network Design, Cost trade off, statistical dimensioning model, LTD and RWA problems, Routing and wavelength assignment, Wavelength conversion.						
Unit – V						**10Hrs**
Control and Management: Network management functions, Management frame work, Information model, Management protocols, Layers within optical layer performance and fault management, Impact of transparency, BER measurement, Optical trace, Alarm and configuration management.						

Course Outcomes

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

CO1	Justify the use of optical components, transmission techniques and network management concepts.
CO2	Analyze the performance characteristics of transmitting and receiving components and systems.
CO3	Create a modulation scheme, topology for WDM network and apply network management functions.
CO4	Develop and demonstrate techniques used in optical communication links.

Reference Books

1.	Optical Networks, Rajiv Ramswami, N Sivaranjan, 3rd Edition, 2009, M Kauffman Publishers, *ISBN*-10: 9780123740922.
2.	Optical Fiber Communication, Gerd Keiser, 4th Edition, 2011, McGraw Hill, *ISBN*-10: 1259006875.
3.	Fiber Optics Communication Systems, G P Agarwal, 3rd Edition, 2002, John Wiley and Sons, New York, *ISBN*-978-0470505113.
4.	Optical Fiber Communications, John M Senoir, 3rd Edition, 2009, Pearson Education, *ISBN*-13: 978-0-13-032681.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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						
SATELLITE NAVIGATION SYSTEMS (Professional Elective-D2)						
Course Code	**:**	**18MRM2D2**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**

Unit – I	**10Hrs**
An Introduction to Radar: Basic Radar, The simple form of the Radar Equation, Radar Block Diagram, Radar Frequencies, Application of radar, Types of Radars. **The Radar Equation**: Introduction, Detection of signals in Noise, Receiver Noise and the Signal-to Noise Ratio, Probability of Detection and False alarm, Radar Cross Section of the targets, Transmitter power, Pulse repetition Frequency. **Fundamentals of Pulse Compression Waveforms** Range Resolution, Straddle Loss, Pulse Compression Waveforms, Pulse Compression Gain, Linear Frequency Modulation Waveform, Sidelobe reductions in an LFM waveforms, Ambiguity Function for simple pulse, Phased Coded waveforms, Phased Coded used in Radar.	
Unit – II	**10Hrs**
Information Available from Radar Signals: Basic Radar measurement, Theoretical Accuracy of Radar Measurement, Pulse Compression, LFM Pulse Compression, Target reorganization. **MTI and Pulse Doppler Radar:** Introduction to Doppler and MTI Radar, Delay-Line Cancellers, Staggered Pulse Repetition frequencies, Doppler Filter Banks, Digital MTI processing, Moving Target detector.	
Unit – III	**10Hrs**
Terrestrial Network based positioning and navigation: Fundamentals, positioning in cellular networks, positioning in WLANs, Positioning in Wireless sensor networks.	
Unit – IV	**12Hrs**
Orbits and Reference Systems : Basics of satellite orbits and reference systems, two body problem, orbit elements, timer system and timer transfer using GPS, coordinate systems, GPS orbit design, orbit determination problem, tracking networks, GPS force and measurement models for orbit determination, orbit broadcast ephemeris, precise GPS ephemeris, Tracking problems.	
Unit – V	**10Hrs**
Satellite-based navigation systems: Global Navigation satellite systems (GNSS), GNSS receivers, Augmented systems and assisted GNSS.	

Course Outcomes

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

CO1	Understand the concept of radars and its signal processing techniques, navigation using satellite and terrestrial networks.
CO2	Apply the concepts of radars, cellular networks, WLAN, sensor networks and satellites in determining the user position and navigation.
CO3	Analyze the different parameters of satellite and terrestrial networks for navigation systems.
CO4	Evaluate the radar systems and satellite and terrestrial network based navigation systems

Reference Books:

1.	Introduction to RADAR Systems, M. L Skolnik,2001,TATA Mcgraw-Hill, ISBN: 0-07-044533-8
2.	Principles of Modern Radar Basic Principles, Mark A Richards, James A Scheer, William A Holam, 2012, Yes Dee Publishing Pvt Ltd, ISBN:978-1891121524 .
3.	GPS - Theory and Practice, B. Hoffman, Wellenhof, H. Lichtenegger and J. Collins, 5th revised edition,2001, Springer, NewYork, ISBN 978-3-211-83534-0.
4.	Satellite and Terrestrial Radio Positioning techniques- A signal processing perspective, Davide dardari, Emanuela Falletti, Marco Luise, 1st Edition, 2012, Elsevier Academic Press, ISBN: 978-0-12-382084-6.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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						
BROADBAND NETWORKS (Professional Elective-D3)						
Course Code	**:**	**18MDC2D3**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**03Hrs**
Unit – I						**10Hrs**
Background of LTE: Introduction, ITU Activities, Drivers For LTE, Standardization of LTE. **Overview of LTE Radio Access:** Basic principles, LTE release 9, LTE release 10 and IMT-Advanced, Terminal capabilities.						
Unit – II						**10Hrs**
Radio-Interface Architecture: Overall System Architecture, Radio Protocol Architecture, Control-Plane Protocols.						
Unit – III						**10Hrs**
Physical Transmission Resources: Overall Time–Frequency Structure, Normal Sub frames and MBSFN Sub frames, Carrier Aggregation, Frequency-Domain Location of LTE Carriers, Duplex Schemes.						
Unit – IV						**12Hrs**
Spectrum: Spectrum for LTE, Flexible Spectrum Use, Flexible Channel Bandwidth Operation, Carrier Aggregation For LTE, Multi-Standard Radio Base Stations.						
Unit – V						**10Hrs**
RF Characteristics of 4G: Overview of RF Requirements for LTE, Output Power Level Requirements, Transmitted Signal Quality, Unwanted Emissions Requirements, **Overview of 5G:** Global initiatives and Standardization activities, Use cases and requirements, Spectrum challenges,5G spectrum landscape and requirements						
Course Outcomes **After successful completion of this course the student will be able to:**						
CO1	Discuss the standardization, resources and requirements of 4G and 5G technologies.					
CO2	Analyze the architectures of 4G technologies.					
CO3	Recommend the transmission resources and Spectrum to design LTE system and 5G system.					
CO4	Asses the LTE system from RF perspective.					
Reference Books						
1.	4G LTE/LTE-Advanced for Mobile Broadband, Erik Dahlman, Stefan Parkvall, and Johan Sköld, Academic Press,2011, ISBN: 978-0-12-385489-6.					
2.	Advanced WirelessCommunications-4G Technologies, Savo Glisic, 2004, John Wiley & Sons Ltd, ISBN:13 978-0-470-01593-3 (HB), ISBN:10 0-470-01593-4 (HB).					
3.	5G Mobile and Wireless Communications, Edited by Afif Osseiran, Jose F. Monserrat and Patrick Marsch, Cambridge University Press, 2016. ISBN:9781107130098.					
4.	5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall, and Johan Sköld, 1st Edition, Academic Press,2018.ISBN:978012814230.					

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

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Total CIE (Q+T+A) 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
BUSINESS ANALYTICS
(Global Elective-G01)

Course Code	**:**	**18CS2G01**	**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**	**SEE Marks**	**:**	**100**
Hours	**:**	**39L**	**SEE Duration**	**:**	**3 Hrs**

Unit – I | **08 Hrs**

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.

Unit – II | **08 Hrs**

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.

Unit – III | **08 Hrs**

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.

Unit – IV | **08 Hrs**

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.

Unit –V | **07 Hrs**

Decision Analysis

Formulating Decision Problems, Decision Strategies with and without Outcome, Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

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	Business analytics Principles, Concepts, and Applications FT Press Analytics, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, 1st Edition, 2014, ISBN-13: 978-0133989403, ISBN-10: 0133989402
2	The Value of Business Analytics: Identifying the Path to Profitability, Evan Stubs , John Wiley & Sons, ISBN:9781118983881 |DOI:10.1002/9781118983881,1st Edition 2014
3	Business Analytics, James Evans, Pearsons Education 2nd Edition, ISBN-13: 978-0321997821 ISBN-10: 0321997824
4	Predictive Business Analytics Forward Looking Capabilities to Improve Business, Gary Cokins and Lawrence Maisel, 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). 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. 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) Minor project.

Total CIE (Q+T+A) 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 (Global Elective-G02)						
Course Code	**:**	**18CV2G02**		**CIE**	**:**	**100 Marks**
Credits L: T: P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

UNIT – I	**7 Hrs**

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	**9 Hrs**

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	**9 Hrs**

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	**7 Hrs**

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	**7 Hrs**

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.

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.

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 (Q+T+A) 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						
MODELING USING LINEAR PROGRAMMING (Global Elective-G03)						
Course Code	**:**	**18IM2G03**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**
Linear Programming: Introduction to Linear Programming problem **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables	
Unit – II	**08 Hrs**
Advanced Linear Programming : Two Phase simplex techniques, Revised simplex method **Duality:** Primal-Dual relationships, Economic interpretation of duality	
Unit – III	**08 Hrs**
Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Post optimal analysis - changes affecting feasibility and optimality	
Unit – IV	**08 Hrs**
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.	
Unit –V	**07 Hrs**
Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	

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	Operation Research An Introduction, Taha H A, 8th Edition, 2009, PHI, ISBN: 0130488089.
2	Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg - John 2nd Edition, 2000, Wiley & Sons (Asia) Pvt Ltd, ISBN 13: 978-81-265-1256-0
3	Introduction to Operation Research, Hiller, Liberman, Nag, Basu, 9th Edition, 2012, Tata McGraw Hill ISBN 13: 978-0-07-133346-7
4	Operations Research Theory and Application, J K Sharma, 4th Edition, 2009, Pearson Education Pvt Ltd, 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 (Q+T+A) 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 (Global Elective-G04)						
Course Code	**:**	**18IM2G04**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**

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.

Unit – II	**08 Hrs**

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

Unit – III	**08 Hrs**

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

Unit – IV	**08Hrs**

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

Unit-V	**07 Hrs**

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.

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	Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, 8th Edition, 2010, Tata McGraw Hill Publication, ISBN 0-07-007793-2.
2	A Guide to the Project Management Body of Knowledge (PMBOK Guide), Project Management Institute, 5th Edition, 2013, ISBN: 978-1-935589-67-9
3	Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, 11th Edition, 2013, John Wiley & Sons Inc., ISBN 978-1-118-02227-6.
4	Project Management – Planning and Controlling Techniques, Rory Burke, 4th Edition, 2004, John Wiley & Sons, 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 (Q+T+A) 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						
ENERGY MANAGEMENT (Global Elective-G05)						
Course Code	**:**	**18CH2G05**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

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	**08 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	**08 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	**08Hrs**

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
After successful completion of this course the student will be able 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). 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. 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) Minor project.

Total CIE (Q+T+A) 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 (Global Elective-G06)						
Course Code	**:**	**18ME2G06**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2M Learning and Artificial Intelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.	
Unit – II	**08 Hrs**
The Concept of the IIoT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture.	
Unit – III	**08 Hrs**
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.	
Unit – IV	**08 Hrs**
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	
Unit –V	**08 Hrs**
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.	

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

Total CIE (Q+T+A) 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 (Global Elective-G07)						
Course Code	**:**	**18ME2G07**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Classification and Selection of Materials: Classification of materials. Properties required in Engineering materials, Criteria of selection of materials. Requirements / needs of advance materials.	
Unit – II	**08 Hrs**
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.	
Unit – III	**08 Hrs**
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	
Unit – IV	**08 Hrs**
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.	
Unit –V	**08 Hrs**
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials	

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

Total CIE (Q+T+A) 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 (Global Elective-08)						
Course Code	**:**	**18CHY2G08**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit-I — **08 Hrs**

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.

Unit – II — **08 Hrs**

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**.**

Unit -III — **08 Hrs**

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.

Unit –IV — **07 Hrs**

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.

Unit –V — **08 Hrs**

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.	
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,2012 , ISBN: 978-0387743646
2	The Science and Engineering of Materials, K Balani, Donald R Askeland, 6th Edition- Cengage, Publishers,2013, ISBN: 13: 978-8131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, 2014, ISBN: 13: 978-0137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, 2010, ISBN: 10-9781498761666, 1498761666

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

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Total CIE (Q+T+A) 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 (Global Elective-09)						
Course Code	**:**	**18PHY2G09**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I **08 Hrs**

Crystal Structure

Discussion of lattice and lattice parameters, seven crystals systems, crystal planes, Miller indices, Interplanar distance, Packing fraction, Structure of different crystals-NaCl and Diamond, Bragg's law, Powder method, Bragg's spectrometer, Qualitative Analysis of Crystal structure using XRD, Reciprocal lattice, Crystal defects-Point, Line, Planar and Volume defects.

Unit – II **08 Hrs**

Dielectric Materials

Basic concepts, Langevin's Theory of Polarisation, Types of Polarisation, Dipolar relaxation, Frequency Dependence of total polarization (polarizability as a function of frequency), Qualitative discussion of Internal Field and Claussius Mossotti, Dielectric loss spectrum, Dielectric strength, Dielectric Breakdown, Breakdown mechanisms in solid dielectrics, Applications of Solid Insulating materials in capacitors and Liquid insulating materials in Transformers, Dielectric Heating, Piezoelectricity, Direct and Inverse Piezoelectric effect, Coupling factor, spontaneous polarization, Piezolelectricty in Quartz, Various piezoelectric materials- PZT, PVDF, Ferroelectricity, Barium titanate, Poling in Ceramics.

Unit – III **08 Hrs**

Magnetic Materials

Review of Dia, Para and Ferromagnetic materials, Weiss theory of Ferromagnetism, Hysteresis effect, Magnetostriction, Anti-ferromagnetism, Ferrimagnetsim, Soft and Hard magnetic materials, examples and applications in Transformer cores and Magnetic storage devices, Superconductors, properties, Types of Superconductors, BCS theory, High Temperature Superconductors, Applications in Cryotron and SQUID.

Unit – IV **07 Hrs**

Semiconducting Materials

Semiconductors-Direct and Indirect band gap semiconductors, Importance of Quantum confinement-quantum wires and dots, size dependent properties, Top down approach, Fabrication process by Milling and Lithography, Bottom up approach, fabrication process by vapour phase expansion and vapor phase condensation, Polymer semi-conductors-Photo conductive polymers, Applications.

Unit –V **08 Hrs**

Novel Materials

Smart materials-shape memory alloys, Austenite and Martensite phase, Effect of temperature and mechanical load on phase transformation, Pseudoeleasticity, Transformation hysteresis, Superelasticity, Characterization technique-Differntial Scanning calorimetry, Preparation technique-spin coating, Nitinol, CuAlNi alloy and applications.

Biomaterials-Metallic, ceramic and polymer biomaterials, Titanium and Titanium alloys, Carbon nanotubes, Graphene- Properties and Applications.

Course Outcomes

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

CO1	Apply the principles of Physics in Engineering.
CO2	Apply the knowledge of Physics for material analysis.
CO3	Identify and Analyze Engineering Problems to achieve practical solutions.
CO4	Develop solutions for Problems associated with Technologies.

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 9971-51-780

3.	Engineering Physics, Dr.M N Avadhanulu, Dr. P G Kshirsagar, S Chand Publishing, Reprint 2015.
4.	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, 6th Edition, Cengage Learning, ISBN-13:978-0-495-66802-2.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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 STATISTICAL METHODS (Global Elective-G10)						
Course Code	**:**	**18MAT2G10**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Sampling Techniques: Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement), Sampling distribution of proportions, Expectation and standard error of sample mean and proportion, Sampling distributions of differences and sums.	
Unit – II	**08 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, Confidence intervals-population mean (large sample).	
Unit – III	**08 Hrs**
Tests of Hypothesis: Principles of Statistical Inference, Formulation of the problems with examples. Simple and composite hypotheses. Null and alternative hypotheses. Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Exact and asymptotic tests of proportions. Chi squared test for goodness of fit (Relevant case studies).	
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 (Relevant case studies).	
Unit –V	**09 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.	

Course Outcomes
After going through this course the student will be able 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	Analyse 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.

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, Douglas C. Montgomery and George C. Runger, 6th Edition, John Wiley & Sons, 2014, ISBN:13 9781118539712, ISBN (BRV):9781118645062.
3.	Fundamentals of Mathematical Statistic-A Modern Approach, S.C. Gupta and V.K. Kapoor, 10th Edition, 2000, 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.

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

CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). 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. 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) Minor project.

Total CIE (Q+T+A) 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