RV COLLEGE OF ENGINEERING®

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

Scheme and Syllabus of I to IV Semesters
(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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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 tosolve 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 Signal Processing & 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

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RVCOLLEGE OF ENGINEERING®, BENGALURU - 560059
(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF TELECOMMUNICATION ENGINEERING

M.Tech in DIGITAL COMMUNICATION ENGINEERING

<table>
<tr><th colspan="9">FIRST SEMESTER CREDIT SCHEME</th></tr>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2">Course Code</th><th rowspan="2">Course Title</th><th rowspan="2">BoS</th><th colspan="4">Credit Allocation</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>Credits</th></tr>
<tr><td>1.</td><td>18MAT11B</td><td>Probability Theory And Linear Algebra</td><td>MAT</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>2.</td><td>18MDC12</td><td>Advanced Digital Communication</td><td>TE</td><td>3</td><td>1</td><td>1</td><td>5</td></tr>
<tr><td>3.</td><td>18MRM13</td><td>RF Circuits-I</td><td>TE</td><td>3</td><td>1</td><td>1</td><td>5</td></tr>
<tr><td>4.</td><td>18HSS14</td><td>Professional Skills Development</td><td>HSS</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>5.</td><td>18MRM1AX</td><td>Elective -A</td><td>TE</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td>6.</td><td>18MRM1BX</td><td>Elective - B</td><td>TE</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
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<tr><th colspan="9">SECOND SEMESTER CREDIT SCHEME</th></tr>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2">Course Code</th><th rowspan="2">Course Title</th><th rowspan="2">BoS</th><th colspan="4">Credit Allocation</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>Credits</th></tr>
<tr><td>1.</td><td>18MRM21</td><td>RF Circuits-II</td><td>TE</td><td>3</td><td>1</td><td>1</td><td>05</td></tr>
<tr><td>2.</td><td>18MRM22</td><td>Antenna theory and Design</td><td>TE</td><td>3</td><td>1</td><td>0</td><td>04</td></tr>
<tr><td>3.</td><td>18IEM23</td><td>Research Methodology</td><td>IEM</td><td>3</td><td>0</td><td>0</td><td>03</td></tr>
<tr><td>4.</td><td>18MRM24</td><td>Minor Project</td><td>TE</td><td>0</td><td>0</td><td>2</td><td>02</td></tr>
<tr><td>5.</td><td>18MRM2CX</td><td>Elective-C</td><td>TE</td><td>4</td><td>0</td><td>0</td><td>04</td></tr>
<tr><td>6.</td><td>18MRM2DX</td><td>Elective-D</td><td>TE</td><td>4</td><td>0</td><td>0</td><td>04</td></tr>
<tr><td>7.</td><td>18MRM2GX</td><td>Global Elective – G</td><td>Respective BoS</td><td>3</td><td>0</td><td>0</td><td>03</td></tr>
<tr><td colspan="4">Total number of Credits</td><td>20</td><td>2</td><td>3</td><td>25</td></tr>
<tr><td colspan="4">Total Number of Hours/Week</td><td>20</td><td>4</td><td>6</td><td>30</td></tr>
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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 CircuitsTechnology
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	Satellite 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	CY	Composite Materials Science and Engineering	03
9.	18PHY2G09	PY	Physics of Materials	03
10.	18MAT2G10	MA	Advanced Statistical Methods	03

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DEPARTMENT OF TELECOMMUNICATION ENGINEERING

M.Tech in DIGITAL COMMUNICATION ENGINEERING

<table>
<tr><td colspan="9" align="center">THIRD SEMESTER CREDIT SCHEME</td></tr>
<tr><td rowspan="2">Sl. No.</td><td rowspan="2">Course Code</td><td rowspan="2">Course Title</td><td rowspan="2">BoS</td><td colspan="4" align="center">Credit Allocation</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Credits</td></tr>
<tr><td>1</td><td>18MDC31</td><td>Wireless Communication</td><td>TE</td><td>4</td><td>1</td><td>0</td><td>5</td></tr>
<tr><td>2</td><td>18MRM32</td><td>Internship</td><td>TE</td><td>0</td><td>0</td><td>5</td><td>5</td></tr>
<tr><td>3</td><td>18MRM33</td><td>Major Project : Phase-I</td><td>TE</td><td>0</td><td>0</td><td>5</td><td>5</td></tr>
<tr><td>4</td><td>18MDC3EX</td><td>Professional Elective-E</td><td>TE</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="4" align="center">Total number of Credits</td><td>8</td><td>1</td><td>10</td><td>19</td></tr>
<tr><td colspan="4" align="center">Total Number of Hours/Week</td><td>8</td><td>2</td><td>20</td><td>30</td></tr>
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<table>
<tr><td colspan="3" align="center">SEMESTER : III</td></tr>
<tr><td colspan="3" align="center">GROUP E: PROFESSIONAL ELECTIVES</td></tr>
<tr><td>Sl. No.</td><td>Course Code</td><td align="center">Course Title</td></tr>
<tr><td>1.</td><td>18MDC3E1</td><td>Short Range Wireless Communication</td></tr>
<tr><td>2.</td><td>18MDC3E2</td><td>Software Defined Networks.</td></tr>
<tr><td>3.</td><td>18MDC3E3</td><td>Network Security</td></tr>
</table>

<table>
<tr><td colspan="9" align="center">FOURTH SEMESTER CREDIT SCHEME</td></tr>
<tr><td rowspan="2">Sl. No.</td><td rowspan="2">Course Code</td><td rowspan="2">Course Title</td><td rowspan="2">BoS</td><td colspan="4" align="center">Credit Allocation</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Credits</td></tr>
<tr><td>1</td><td>18MRM41</td><td>Major Project : Phase-II</td><td>TE</td><td>0</td><td>0</td><td>20</td><td>20</td></tr>
<tr><td>2</td><td>18MRM42</td><td>Technical Seminar</td><td>TE</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="4" align="center">Total number of Credits</td><td>0</td><td>0</td><td>22</td><td>22</td></tr>
<tr><td colspan="4" align="center">Total Number of Hours / Week</td><td>0</td><td>0</td><td>44</td><td>44</td></tr>
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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, GilbertStrang, 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.

Radio Frequency and Microwave Engineering

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, InderBahl 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
CreditsL: 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** :	**03Hrs**

Unit – I	07Hrs
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	**08Hrs**
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	**08Hrs**
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	**08Hrs**
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	**08Hrs**
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:

CO 1	Explain the fundamental principles of electromagnetics, merits and demerits of CEM techniques.
CO 2	Compute electric field and magnetic field for simple linear structure using analytical and computational techniques.
CO 3	Apply residual calculus in deriving and analyzing various computational techniques
CO 4	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.

Radio Frequency and Microwave Engineering

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	:	03Hrs

Unit – I	08Hrs
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	08Hrs
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	08Hrs
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	08Hrs
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	07Hrs
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.

Radio Frequency and Microwave Engineering

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**	:	**03Hrs**
Unit – I						**08Hrs**

Overview of C++:
Principles of object-objective Programming, Tokens, Expressions and control structures, Functions in C++, Classes and Objects, Destructors and Constructors.

Unit – II	**08Hrs**

Concepts of Object Oriented Programming:
Operator Overloading, Inheritance: Extending Classes, Pointers, Virtual functions and polymorphism, Exception handling, Class Templates.

Unit – III	**08Hrs**

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,CompanyLtd.,ISBN:0070593620.
2.	Data Structures, Algorithms, and Applications in C++, SartajSahni, 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.

Radio Frequency and Microwave Engineering

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, KazemSohraby, Daniel Minoli, TaiebZnati, 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, WaltenegusDargie 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.

Radio Frequency and Microwave Engineering

			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 typesPrimary 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.

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.

Radio Frequency and Microwave Engineering

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.

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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.

Radio Frequency and Microwave Engineering

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.

Radio Frequency and Microwave Engineering

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,PHarisson, 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-JinSong,TadaoNagatsuma, "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.

Radio Frequency and Microwave Engineering

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)

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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.

Radio Frequency and Microwave Engineering

		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, Davidedardari, EmanuelaFalletti, 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					
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 forBusiness 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

ReferenceBooks

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 2ndEdition, ISBN-13:978-0321997821ISBN-10:0321997824
4	Predictive Business Analytics Forward Looking Capabilities to Improve Business,Gary Cokins and Lawrence Maisel, Wiley; 1stEdition, 2013.

Radio Frequency and Microwave Engineering

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.

Radio Frequency and Microwave Engineering

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-RelatedHealthIncidents,Eyestrain,RepetitiveMotion,LowerBackPain,VideoDisplay 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.

Radio Frequency and Microwave Engineering

	Reference Books
1.	Maintenance Engineering Handbook, Higgins & Morrow, SBN 10: 0070432015 / ISBN 13: 9780070432017, Published by McGraw-Hill Education. Da InformationServices.
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.

Radio Frequency and Microwave Engineering

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.

Radio Frequency and Microwave Engineering

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**	**SEEMarks**	:	**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 Exchangersandclassification.

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, KhandelwalK 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,1stEdition, 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 wayforward. 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, EmreCevikcan, Springer, 2018 ISBN 978-3-319-57869-9.
3	Designingtheindustry - Internet of things connecting the physical, digital and virtual worlds, OvidiuVermesan and Peer Friess, Rivers Publishers, 2016 ISBN978-87-93379-81-7
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.

Radio Frequency and Microwave Engineering

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.

Radio Frequency and Microwave Engineering

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.

Radio Frequency and Microwave Engineering

SEMESTER : II					
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Global Elective-08)					
Course Code	:	18CHY2G08	CIE Marks	:	100
CreditsL: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, Particlereinforced

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 – monolithicceramics

– 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 metallurgyprocess–diffusionbonding–stircasting– squeezecasting,asprayprocess,

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 ofmaterials available
CO3	Will be capable of comparing/evaluating the relative merits of using alternatives forimportant 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 EditionSpringer-verlag Gmbh,2012 , ISBN: 978-0387743646
2	The Science and Engineering of Materials, K Balani, Donald R Askeland, 6thEdition- 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,CRCPress-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 ClaussiusMossotti, 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 MillingandLithography,Bottomupapproach,fabricationprocessbyvapourphaseexpansionand
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 andapplications.
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, ISBN10-8122436978.

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.

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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 ofdifferences 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 ANOVAmodels-oneobservationpercell,multiplebutequalnumberofobservationpercell(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

Radio Frequency and Microwave Engineering

SYLLABUS
FOR
SEMESTER III & IV

SEMESTER : III					
WIRELESS COMMUNICATION (Theory)					
Course Code	:	18MDC31	**CIE Marks**	:	**100**
Credits L:T:P	:	4:1:0	**SEE Marks**	:	**100**
Hours	:	52L+26T	**SEE Duration**	:	**3 Hrs**
Unit – I					**10Hrs**
Wireless channel: Physical modeling for wireless channels, input/output model of wireless channel, time and frequency response.					
Unit – II					**10Hrs**
Point to point communication: Detection in Rayleigh fading channel, time diversity, antenna diversity, frequency diversity.					
Unit – III					**10Hrs**
Capacity of wireless channels: AWGN channel capacity, resources of AWGN channel, Linear time invariant Gaussian channels, capacity of fading channels.					
Unit – IV					**12Hrs**
MIMO Systems: Introduction, Space Diversity and Systems Based on Space Diversity, Smart antenna system and MIMO, MIMO based System architecture, MIMO exploits multipath, Space time Processing, Antenna considerations for MIMO, MIMO channel Modeling, MIMO Channel measurement, MIMO Channel capacity, Space Time Coding, Advantages and Applications of MIMO, MIMO applications in 3G.					
Unit – V					**10Hrs**
Spatial multiplexing and channel modeling: multiplexing capability of MIMO channels, physical modeling of MIMO channels, modeling MIMO fading channels.					

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

CO1	Describe physical modeling for wireless channel and diversity techniques.
CO2	Analyze the Modeling of MIMO fading channels.
CO3	Evaluatediversity techniques and multiplexing capability of MIMO channels.
CO4	Design a MIMO system with smart antennas in wireless communication applications.

Reference Books

1.	Fundamentals of wireless communication, David Tse, P. Viswanath, 2006,Cambridge,.ISBN 0-521-68749-7.
2.	Wireless communication, UpenDalal, Oxford university Press, 2009, ISBN-13:978-0-19-806066-6.
3.	Wireless communications, Andreas Molisch, 2nd Edition, 2009,Wiley, *ISBN*: 978-0-470-74187-0.
4.	Mobile Communication Engineering Theory and applications, William C Y Lee,2008, McGraw Hill Education, ISBN 10: 0070252203.

Scheme ofContinuous 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.

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SEMESTER : III					
INTERNSHIP					
Course Code	:	18MRM32		**CIE Marks**	:	100
Credits L:T:P	:	0:0:5		**SEE Marks**	:	100
Hours/week	:	10		**SEE Duration**	:	3 Hrs

GUIDELINES

1) The duration of the internship shall be for a period of 8 weeks on full time basis after II semester final exams and before the commencement of III semester.

2) The student must submit letters from the industry clearly specifying his / her name and the duration of the internship on the company letter head with authorized signature.

3) Internship must be related to the field of specialization of the respective PG programme in which the student has enrolled.

4) Students undergoing internship training are advised to report their progress and submit periodic progress reports to their respective guides.

5) Students have to present the internship activities carried out to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final internship report. However, interim or periodic reports as required by the industry / organization can be submitted as per the format acceptable to the respective industry /organizations.

6) The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

7) The broad format of the internship final report shall be as follows
   - Cover Page
   - Certificate from College
   - Certificate from Industry / Organization
   - Acknowledgement
   - Synopsis
   - Table of Contents
   - Chapter 1 - Profile of the Organization : Organizational structure, Products, Services, Business Partners, Financials, Manpower, Societal Concerns, Professional Practices,
   - Chapter 2 - Activities of the Department
   - Chapter 3 - Tasks Performed : summaries the tasks performed during 8 week period
   - Chapter 4 – Reflections : Highlight specific technical and soft skills that you acquired during internship
   - References & Annexure

Course Outcomes
After going through the internship the student will be able to:
CO1: Apply engineering and management principles
CO2: Analyze real-time problems and suggest alternate solutions
CO3: Communicate effectively and work in teams
CO4: Imbibe the practice of professional ethics and need for lifelong learning.

Scheme of Continuous Internal Evaluation (CIE):
The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor. The committee shall assess the presentation and the progress reports in two reviews.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
Review-I	Explanation of the application of engineering knowledge in industries, ability to comprehend the functioning of the organization/ departments,	45%
Review-II	Importance of resource management, environment and sustainability presentation skills and report writing	55%

Scheme for Semester End Evaluation (SEE):
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.

SEMESTER : III					
MAJOR PROJECT : PHASE-I					
Course Code	:	**18MRM33**		**CIE Marks**	:	**100**
Credits L:T:P	:	**0:0:5**		**SEE Marks**	:	**100**
Hours/week	:	**10**		**SEE Duration**	:	**3 Hours**
GUIDELINES					

1. The Major Project work comprises of Phase-I and Phase-II. Phase-I is to be carried out in third semester and Phase-II in fourth semester.
2. The total duration of the Major project Phase-I shall be for 16 weeks.
3. Major project shall be carried out on individual student basis in his/her respective PG programme specialization. Interdisciplinary projects are also considered.
4. The allocation of the guides shall be preferably in accordance with the expertise of the faculty.
5. The project may be carried out on-campus/industry/organization with prior approval from Internal Guide, Associate Dean and Head of the Department.
6. Students have to complete Major Project Phase-I before starting Major Project Phase-II.
7. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes
After going through this 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 project and resource managements skills, professional ethics, societal concerns
CO4:   Synthesize self-learning, sustainable solutions and demonstrate life-long learning

Scheme of Continuous Internal Examination (CIE)
Evaluation shall be carried out in two reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
Review-I	Selection of the topic, Literature Survey, Problem Formulation and Objectives	45%
Review-II	Methodology and Report writing	55%

Scheme for Semester End Evaluation (SEE):
Major Project Phase-I evaluation shall be done by an external examiner (domain expert) and respective guide as per the schedule. Maximum of four candidates per batch shall be allowed to take examination. The batches are to be formed based on specific domain of work.

SEMESTER : III					
SHORT RANGE WIRELESS COMMUNICATION **(ProfessionalElective-E1)**					
Course Code	:	18MDC3E1		**CIE Marks**	:	100
Credits L:T:P	:	4:0:0		**SEE Marks**	:	100
Hours	:	52L		**SEE Duration**	:	3 Hrs

Unit – I	10Hrs

Introduction to Short Range Wireless Communication (SWC): Growth of standards, Market, Wireless architecture, wireless parameters, Enabling factors, Design rules for SRC, Short-range vs medium/long range communications., High rate vs Low rate communications, Review of frequency regulations and available frequency bands, State of the Art SWC systems: WLAN, Bluetooth, ZigBee, NFC, UWB, BAN, 60GHz, LiFi, and VLC.

Unit – II	10Hrs

Channel Estimation for high-rate systems: High rate UWB and 60GHz communications - Overview and Application Scenario's, ECMA-368 High rate UWB standard, ECMA-387 Millimeter wave radio standard, IEEE 802.15.3C, Channel models for high rate systems, Review of channel estimation techniques, Impact on channel estimation error on performance.

Unit – III	10Hrs

Adaptive Modulation and coding for high rate systems: Adaptive modulation and coding, AMC in MB-OFDM systems, WPAN link architecture in ECMS-368, Packet level model for UWB channels with shadowing, WPAN link performance analysis, AMC in 60GHz millimeter wave radio systems, modulation techniques and system architectures for multi-Gb/s, RF Packaging and Antenna design issues.

Unit – IV	12Hrs

PHY Layer Design Issues for High Data Rate (Gbps) communication: Principles of MIMO systems, MIMO for UWB systems, Adaptive Antenna Array Systems Design, active phased array based on analog beam-forming, PAPR Reduction for Discrete-time OFDM Signals, Soft Iterative Equalization for Clipped and Filtered COFDM Signals, power-amplifier utilization - significantly improved by clipping and filtering; matching receive algorithm for equalization of in-band distortion noise.

Unit – V	10Hrs

Low rate systems & Emerging concepts in Short Range communications: ZigBee networks and low rate UWB communications - Overview and application examples, ZigBee, Impulse radio based UWB (IEEE 802.15.4a), Low latency MAC for WPANs (IEEE 802.15.4e), Active RFID (IEEE 802.15.4f), Smart utility Networks (IEEE 802.15.4g), Energy efficiency in Low rate systems- Background, Energy saving MACs.
UROOF' (UWB radio-over-optical-fibre), UROOF - user applications and basic system configuration, Fundamentals of UROOF Technologies, Link Analysis of UROOF Systems, Analysis of UWB Technologies for UROOF, Visible Light Communications, Discrete Multitone Modulation, Potential applications of VLC, Technical challenges of implementing VLC.

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

CO1:	Explain the architectures and operations of state-of-the-art short range wireless networking standards.
CO2:	Analyze the error performance of short range communication systems in presenceofnoise and other interferences.
CO3:	Gain in-depth knowledge about multicarrier and multiantenna techniques and their applicationsin current and emerging communication systems.
CO4:	Identify various technical challenges on low rate systems and short rangecommunication systems.

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Reference Books	
1.	Reliable Communications for Short-Range Wireless Systems, Ismail Guvenc, Sinan Gezici, ZaferSahinoglu and Ulas C. Kozat, 1st Edition, 2011, Cambridge University Press, ISBN: 978-0-521-76317-2.
2.	Essentials of short-range wireless, Nick Hunn, 1st Edition, 2010, Cambridge University Press, ISBN: 978-0521760690.
3.	Short-range Wireless Communication, Alan Bensky, 3rd Edition, 2019, Newnes, , ISBN: 9780128154069, 9780128154052.
4.	ShortRange Wireless Communications: Emerging Technologies and Applications, Rolf Kraemer, Marcos D. Katz, 1st Edition, 2009, John Wiley & Sons Ltd, ISBN:9780470699959,9780470740125.

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 : III						
SOFTWARE DEFINED NETWORKS **(ProfessionalElective-E2)**						
Course Code	:	18MDC3E2		**CIE Marks**	:	100
Credits L:T:P	:	4:0:0		**SEE Marks**	:	100
Hours	:	52L		**SEE Duration**	:	3 Hrs
Unit – I						**10Hrs**
Software Defined Networking: Introduction, Modern Data Center, Traditional Switch Architecture, Layer 2 & 3 Control, Evolution of switches and control planes, Data Center Innovation & Needs, The Evolution of Networking Technology, Forerunners of SDN, Open Source Contributions and Network Virtualization.						
Unit – II						**10Hrs**
How SDN Works: Fundamental Characteristics of SDN, SDN Operation SDN Devices, SDN Controller, SDN Applications. **The Open Flow Specification**: Open Flow Overview, Open Flow 1.0 and Open Flow Basics, Open Flow 1.1, 1.2, and 1.3 Additions and Open Flow Limitations.						
Unit – III						**10Hrs**
Alternative Definitions of SDN: Potential Drawbacks of Open SDN, Alternate SDN Methods, Network Functions Virtualization, Alternatives Overlap and Ranking, SDN in the Data Center: Definition, Data Center Demands, Tunneling Technologies, Path Technologies, Ethernet Fabrics, SDN Use Cases in the Data Centerand Real-World Data Center Implementations.						
Unit – IV						**12Hrs**
SDN in Other Environments: Consistent Policy Configuration**,** Global Network View**,** WANs**,** Service Provider and Carrier Networks**,** Campus Networks**,** Hospitality Networks**,** Mobile Networks**,** In-Line Network Functions, and Optical Networks. **Players in the SDN Ecosystem:** Academic Research Institutions**,** Industry Research LabsandNetwork Equipment Manufacturers**.**						
Unit – V						**10Hrs**
SDN Applications: Reactive versus Proactive Applications**,** A Simple Reactive Java Application**,** Background on various Controllers like Floodlight Controller**,** Open Daylight Controller**,** Cisco XNC Controller**,** andHewlett-Packard Controller**.** Switch Considerations**,** Creating NV Tunnels**,** Offloading Flows in the Data Center**,** Access Control for the Campus**,** Traffic Engineering for Service Providers**.**						
Course Outcomes **After successful completion of this course the student will be able to:** CO1: Explain and discuss the basic concepts and architectural differences of conventional networking approaches and SDN. CO2: Analyze and apply implementation of SDN through Open Flow Switches. CO3: Apply the principles of SDN for the design of data centre using SDN elements of reputed vendors. CO4: Design and implement software defined network application on SDN-based networking devices						
Reference Books						
1.	Software Defined Networks: A Comprehensive approach, Paul Goransson, Chuck Black, Timothy Culver, 2nd Edition, Elsevier, ISBN-13: 978-0128045558, ISBN-10: 0128045558, 2014.					
2.	Software Defined Networking design and deployment, Patricia A. Morreale, James M. Anderson, 1st Edition, CRC Press, ISBN-10: 1482238632, ISBN-13: 978-1482238631, 2015.					
3.	SDN: Software Defined Networks: An Authoritative Review of Network, Programmability Technologies, Thomas D. Nadeau, Ken Gray, 1st Edition, ISBN-13: 978-1449342302, ISBN-10: 9781449342302, 2013.					
4.	OpenFlow Cookbook, S., Kingston Smiler, 1st Edition, Packt Publishing, ISBN - 1783987944, 9781783987948, 2015.					

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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.

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SEMESTER : III					
NETWORK SECURITY (ProfessionalElective-E3)					
Course Code	:	18MDC3E3		**CIE Marks**	:	100
Credits L:T:P	:	4:0:0		**SEE Marks**	:	100
Hours	:	52L		**SEE Duration**	:	3 Hrs
Unit – I					10Hrs

Introduction: OSI Security Architecture, Classical Encryption techniques: Symmetric Cipher Model, Substitution Techniques, Transportation Techniques.
Block Ciphers and Data Encryption Standards: Traditional Block Cipher Structure, The Data Encryption Standard, A DES Example, The Strength of DES. **Advanced Encryption Standard:** AES Transformation Functions, AES Key Expansion, An AES Example, AES Implementation.

Unit – II	10Hrs

Public Key Cryptography and RSA: Principles of Public-Key Cryptosystems, The RSA Algorithm.
Other Public-Key Cryptosystems: Diffie-Hellman Key Exchange, Elgamal Cryptographic System, Elliptic Curve Arithmetic,Elliptic Curve Cryptography, Pseudorandom Number Generation Based on an Asymmetric Cipher.

Unit – III	10Hrs

Cryptographic Hash Functions: Applications of Cryptographic Hash Functions, Two Simple Hash Functions, Hash Functions Based on Cipher Block Chaining, Secure Hash Algorithm (SHA), SHA-3.
Message Authentication Codes: Message Authentication Requirements, Message Authentication Functions, Requirements for Message Authentication Codes, Security of MACs, MACs Based on Hash Functions: HMAC, MACs Based on Block Ciphers: DAA and CMAC, Authenticated Encryption: CCM and GCM, Pseudorandom Number Generation Using Hash Functions and MACs.
Digital Signatures: Digital Signatures, Elgamal Digital Signature Scheme, Schnorr Digital Signature Scheme, NIST Digital Signature Algorithm, Elliptic Curve Digital Signature Algorithm, RSA-PSS Digital Signature Algorithm.

Unit – IV	12Hrs

Network Access Control and Cloud Security: Network Access Control, Extensible Authentication Protocol, IEEE 802.1X Port-Based Network Access Control.
Wireless Network Security: Wireless Security, Mobile Device Security, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security.

Unit – V	10Hrs

Electronic Mail Security: Internet Mail Architecture, Email Formats, Email Threats and Comprehensive Email Security, S/MIME, Pretty Good Privacy, DNSSEC, DNS-Based Authentication of Named Entities, Sender Policy Framework, Domain Keys Identified Mail.
IP Security: Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange.

Course Outcomes
After successful completion of this course the student will be able to:
CO1: Describe the issues addressed by Network Security and understand the concepts of cryptography and Network security.
CO2: Apply cryptographic techniques and algorithms to provide security to the transmitted information.
CO3: Analyze the concepts of Authentication and Hash functions.
CO4: Understand and analyze System level security issues.

Reference Books

1.	Cryptography And Network Security - Principles and Practices, William Stallings Pearson Education Limited, 7th Edition, 2017.ISBN-13:978-0134444284 ISBN-10:0134444280.
2.	Cryptography and Network Security, Behrouz A. Forouzan, Tata McGraw-Hill, 2008,*ISBN*-13: 978-0-13-187319-3.

3.	Computer Security: Principles and Practice, William Stallings, Lawrie Brown, Pearson Education Limited, 4th Edition. *ISBN*-10: 9780134794105.
4.	Cryptography and Network Security, AtulKahate, Tata McGraw-Hill, 2003, ISBN-81:203-2186-3.

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 : IV					
MAJOR PROJECT : PHASE-II					
Course Code	:	18MRM41	CIE Marks	:	100
Credits L:T:P	:	0:0:20	SEE Marks	:	100
Hours/Week	:	40	SEE Duration	:	3 Hrs
GUIDELINES					

1. Major Project Phase-II is continuation of Phase-I.
2. The duration of the Phase-II shall be of 16 weeks.
3. The student needs to complete the project work in terms of methodology, algorithm development, experimentation, testing and analysis of results.
4. It is mandatory for the student to present/publish the work in National/International conferences or Journals
5. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes
After going through this 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 project and resource managements skills, professional ethics, societal concerns
CO4: Synthesize self-learning, sustainable solutions and demonstrate life-long learning

Scheme of Continuous Internal Examination (CIE)
Evaluation shall be carried out in three reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
Review-I	Review and refinement of Objectives, Methodology and Implementation	20%
Review-II	Design, Implementation and Testing	40%
Review-III	Experimental Result & Analysis, Conclusions and Future Scope of Work, Report Writing and Paper Publication	40%

Scheme for Semester End Evaluation (SEE):
Major Project Phase-II SEE shall be conducted in two stages. This is initiated after fulfilment of submission of project report and CIE marks.

Stage-1Report Evaluation
Evaluation of Project Report shall be done by guide and an external examiner.

Stage-2Project Viva-voce
Major Project Viva-voce examination is conducted after receipt of evaluation reports from guide and external examiner.
Both Stage-1 and Stage-2 evaluations shall be completed as per the evaluation formats.

SEE procedure is as follows:

	Internal Guide	External Examiner		TOTAL
SEE Report Evaluation	100 marks	100 marks		200 marks
			(A)	(200/2) = 100 marks
Viva-Voce	Jointly evaluated by Internal Guide & External Evaluator		(B)	100 marks
		Total Marks		[(A)+(B)]/2 = 100

SEMESTER : IV					
TECHNICAL SEMINAR					
Course Code	**:**	**18MRM42**	**CIE Marks**	**:**	**50**
Credits L:T:P	**:**	**0:0:2**	**SEE Marks**	**:**	**50**
Hours/Week	**:**	**4**	**SEE Duration**	**:**	**30 min**
GUIDELINES					

1) The presentation shall be done by individual students.
2) The seminar topic shall be in the thrust areas of respective PG programme.
3) The seminar topic could be complementary to the major project work
4) The student shall bring out the technological developments with sustainability and societal relevance.
5) Each student must submit both hard and soft copies of the presentation along with the report.
6) The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes
After going through this course the student will be able to:
CO1: Identify topics that are relevant to the present context of the world
CO2: Perform survey and review relevant information to the field of study.
CO3: Enhance presentation skills and report writing skills.
CO4: Develop alternative solutions which are sustainable

Scheme of Continuous Internal Evaluation (CIE): Evaluation shall be carried out in two reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
Review-I	Selection of Topic, Review of literature, Technical Relevance, Sustainability and Societal Concerns, Presentation Skills	45%
Review-II	Technological Developments, Key Competitors, Report writing	55%

Scheme for Semester End Evaluation (SEE):
The SEE examination shall be conducted by an external examiner and an internal examiner. Evaluation will be done in batches, not exceeding 6 students per batch.