University Institute of Technology (UIT)

Silver Wood Estate, H. P. University, Shimla-171005

(NAAC Accredited "A-Grade" University)

DEPARTMENT
Of
ELECTRONICS & COMMUNICATION ENGINEERING

Course Work Syllabus
For

DOCTOR OF PHILOSOPHY
In
ELECTRONICS & COMMUNICATION ENGINEERING

Effective for the Batch 2021and onwards

Course of Study
For
Doctoral Program

S. No.	Course No.	Course Name	L	T	P	C	Semester End Marks	
							External	Internal
1.	PEC-2001	Advanced Nano scale Devices	3	1	0	4	100	50
2	PEC-2002	Materials for Nano Technology	3	1	0	4	100	50
3	PEC-2003	Space-Time Wireless Communication	3	1	0	4	100	50
4.	PEC-2004	Advanced Wireless Networks	3	1	0	4	100	50
5.	PEC -2005	Advanced Computer Networks and Protocols	3	1	0	4	100	50
6.	PEC -2006	Optoelectronics Devices and Circuits	3	1	0	4	100	50
7.	PEC-2007	Artificial Intelligence	3	1	0	4	100	50
8.	PEC-2008	Design for IOT	3	1	0	4	100	50
9.	PEC-2009	Computational Electro magnetic	3	1	0	4	100	50
10.	PEC-2010	Machine and Deep Learning	3	1	0	4	100	50
11.	PEC-2011	Flexible and Printable Electronics Technology	3	1	0	4	100	50
12.	PEC-2012	Advanced Antenna Theory and Design	3	1	0	4	100	50
13.	PEC-2013	Nano photonics	3	1	0	4	100	50

Legend:

L - Number of lecture hours per week.

T - Number of tutorial hours per week.

P - Number of practical hours per week.

C- Total no. of credit

DETAILED SYLLABUS

Name of the Course	Advanced Nano scale Devices		
Course Code	PEC-2001	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- ❖ To introduce students to the emerging design paradigms in various new nanotechnologies, for device and circuits.
- ❖ To bridge the existing gap between nano electronic device research and nano systems design.

Section	Course Content
Section-A	***Challenges In Nano Science & Nano Technology:*** Quantum mechanical, Physical and Biological aspects of Nano science & Technology, Nano defects, Nano layers and Nano structuring,Growth and Fabrication of Nano structures, Electron transport in nano structures.
Section-B	***Nano Structured Electronic Devices***: Nano tunneling devices, Self organization phenomena at nano crystal surfaces, Engineering of complex nanostructures, Quantum dot nanostructures for single electron devices, Carbon nano tubes and carbon electronics, Quantum electronic devices (QEDs).
Section-C	***Organic Electronics:*** Complex integrated systems and information processing at nano scale, Limits of integrated systems and nano devices.
Section-D	***Concept Of Hetero Structure Devices: O***xide hetero structures, photo voltaic, sensors, actuators, quantum dot hetero structure lasers etc. Nano-MEMS, Introduction to quantum computation and soft computing.

Course Outcomes:

CO1: Obtain the knowledge on advanced Nano scale devices.

CO2: Understand the operation and design Fin FET based circuits.

CO3: Design reliable circuits using nano wire arrays and CNT interconnects.
CO4: Understand the design aspects of application specific Nano scale ICs.

Text Books:

1. Nano science and Nanotechnology in Engineering, V. K. Vardanet. al., World Scientific, 2010.
2. Introduction to Nanotechnology &Nano electronics: Materials, Devices and Measurement Techniques, W. R. Fahrner, Springer, 2005.
3. Introduction to Nano electronics : Science, Technology, Engineering & Applications, V. V. Mitin, V. A. Kochelap, M. A. Satroscio, Cambridge University Press, 2008.
4. Nano electronics and Nano systems, K. Goser, P. Glosekotter, J. Dienstuhi, Springer, 2005.
5. Nano structures, V. A. Shchukin, N. N. Ledentsov, D. Bimberg, Springer, 2007.
6. Semiconductor LASERS I & II: Fundamentals, E. Kapon, Academic Press (Indian edition), 2006.

Reference Books:

1. Optical Materials, John H. Simmons and Kelly S. Potter, Academic Press (Indian edition), 2006.
2. Electronic Properties of Materials, Rolf E. Hummel, Springer (3rd edition).
3. Energy Storage, R. A. Huggins, Springer, 2010.
4. Fundamentals of Photovoltaic Modules and their Applications, G. N. Tiwari, S. Dubey & Julian C. R. Hunt, RSC Energy Series, 2009

Name of the Course	**Materials for Nanotechnology**		
Course Code	**PEC-2002**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- The goal of this course is to provide an insight into the fundamentals of Nano science and nano-technology.
- The course provides basics of nano-materials, quantum mechanics and statistical mechanics.

Section	Course Content
Section-A	***Advantages Of Nano Electrical And Electronic Devices:*** Micro and nano-electro mechanical systems – sensors, actuators, optical switches, bio-MEMS diodes and nano-wire transistors - data memory lighting and displays, filters (IR blocking).
Section-B	***Quantum Optical Devices:*** Fuel cells and photo-voltaic cells – electric double layer capacitors – lead-free solder – nano particle coatings for electrical products. Nano catalyst, smart materials, heterogeneous nano structures and composites.
Section-C	***Nanostructures for Molecular Recognition***: Quantum dots, nano rods, nano tubes molecular encapsulation and its applications – nano porous zealots – self-assembled nano reactors - organic electroluminescent displays.
Section-D	***Drug Deliveries:*** Drug delivery system, nano particle in drug delivery available applications, nanotechnology future application understanding for treatment.

Course Outcomes:

CO1: To acquire the knowledge of basic sciences required to understand the fundamentals of nano materials

CO2: To acquire the knowledge of electronic, optical and magnetic properties of nano materials.

CO3: To get familiarize with the basic concepts of Statistical and Quantum mechanics

Text Books:

1. Micro and Nanofabrication, Zheng Cui, Springer 2005.
2. Nano structured materials, Jackie Y. Ying, Academic press 2001
3. Nanotechnology and nano electronics, W.R, Fahrner, Springer 2005
4. Nano engineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
5. Hand book of Nano science, Engineering, and Technology, William A. Goddard, CRC press 2003.
6. Nano electronics and Information Technology, Rainer Waser, Wiley-VCH 2003.

Reference Books:

1. The MEMS Handbook Frank Kreith, CRC press 2002.
2. Pradeep T “Nano: The Essentials”, McGraw Hill Publishing Co. Ltd., 2007
3. Mick Wilson et al, “Nanotechnology”, Overseas Press (India) Pvt. Ltd., 2005.
4. Charles P. Poole, Jr., Frank J. Owens, “Introduction to nano technology”, Wiley, 2003.
5. Gunter Schmid, “Nano particles: From Theory to Applications”, Wiley VCHV erlag GmbH & Co., 2004.

Name of the Course	**Space Time Wireless Communication**		
Course Code	**PEC-2003**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- To understand the performance of MIMO system, MIMO-OFDM system, and space time block codes (STBC), Altamonte schemes of channel estimation, space time Trellis codes, and other various space time coding schemes and their performances analysis.

Section	Course Content
Section-A	***Introduction:*** MIMO wireless communication, MIMO channel and signal model, A fundamental trade-off, MIMO transceiver design, MIMO in wireless networks, MIMO in wireless standards. Equalizer Noise Enhancement, Equalizer Types, Folded Spectrum and ISI- Free Transmission, Linear Equalizers, Zero Forcing (ZF) Equalizers, Minimum Mean Square Error (MMSE) Equalizer, Maximum Likelihood Sequence Estimation, Decision-Feedback Equalization
Section-B	***Performance Limits Of Multiple-Input Multiple-Output Wire Less Communication Systems:*** MIMO System Model, Capacity in AWGN, Capacity of Flat-Fading Channels, Channel and System Model, Channel Distribution Information (CDI) Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity of Frequency-Selective Fading MIMO System Capacity Derivation, Capacity of MIMO Systems with Static, Capacity of MIMO Systems with Fading Channels
Section-C	***Multiple Antennas and Space-Time Communications:*** Narrowband MIMO Model, Parallel Decomposition of the MIMO Channel MIMO Diversity Gain: Beam forming, Diversity/Multiplexing Tradeoffs, Space-Time Modulation and Coding. ML Detection and Pair wise Error Probability

	Space-Time Block Codes: Altamonte Space-Time Code with Multiple Receive Antennas, Space- Time Block Codes (STBC), STBC for Real Signal Constellations, STBC for Complex Signal Constellations, Decoding of STBC, Performance of STBC, Effect of Imperfect Channel Estimation and Antenna Correlation on Performance
Section-D	***Layered Space-Time Codes:*** LST Transmitters, LST Receivers, QR Decomposition, Interference Minimum Mean Square Error (MMSE) Suppression Combined with Interference Cancellation, Iterative LST Receivers, VBLAST architecture, DBLAST Architecture. ***Space-Time Trellis Codes:*** Encoder Structure for STTC, Generator Description, And Optimal STTC Based on the Rank, Determinant and Trace Criterion, Performance Comparison for Codes Based on Different Design Criteria, Design of Space-Time Trellis Codes on Fast Fading Channels.

Course Outcomes:

CO1: At the end of the course, the students should be able to: Recognize the basic concepts of space time coding techniques and their used in MIMO and MIMO-OFDM system.

CO2: Evaluate the performance of MIMO System in different fading scenario.

CO3: Evaluate the performance of various space time block codes and space time trellis codes.

CO4: Analyze the concept of various layered architecture in MIMO system.

Text Books:

1. Larsson, Erik G. and PetreStoica, Space-Time Block Coding for WirelessCommunications, Cambridge University Press(2008).
2. David, Tse and Viswanath, Pramod, Fundamentals of Wireless CommunicationCambridge University Press(2006).

Reference Books:

1. Fitzek, Frank H.P., Katz and Marcos D., Cooperation in Wireless Networks: Principlesand applications, Springer (2007)2nded.
2. Arogyaswami,Paulraj, Gore, Dhananjay and Nabar, Rohit., Introduction to Space- Time Wireless Communications, Cambridge, UniversityPress(2008).

<table>
<tr><td>Name of the Course</td><td colspan="3">Advanced Wireless Networks</td></tr>
<tr><td>Course Code</td><td>PEC-2004</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hr Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.</td></tr>
<tr><td colspan="4">Course Objectives:
❖ The objective of this course unit is to study the problematic of service integration in wireless networks focusing on protocol design, wireless network security, implementation and performance issues.</td></tr>
</table>

Section	Course Content
Section-A	***Fundamentals:*** 4G Networks and Composite Radio Environment, Protocol Boosters, Hybrid 4G Wireless Network Protocols, Green Wireless Networks, Physical Layer and Multiple Access, Multicarrier CDMA, Ultra wide Band Signal, MIMO Channels and Space Time Coding. ***Introduction to Wireless Networking***: Introduction, Difference between wireless and fixed telephone networks, WLAN, Development of wireless networks, 3G and 4G Networks, Traffic routing in wireless networks. Wireless Networking, Packet Processing, Network Speed, Packet Buffering.
Section-B	***Bluetooth***: Overview, Radio specification, Base band specification, Links manager specification, Logical link control and adaptation protocol. Introduction to WLL Technology. ***Mobile Network:*** IP packet delivery – Agent advertisement and solicitation – Registration – Tunneling and Encapsulation – Optimizations – Reverse Tunneling – Ipv6., Dynamic Host Configuration protocol, Traditional TCP - Congestion control – Slow start – Fast retransmit/fast recovery – Classical TCP improvements: Indirect TCP – Snooping TCP – Mobile TCP.
Section-C	***Mobility and Resource Management:*** Prioritized Handoff, Cell Residing Time Distribution, Mobility Prediction in Pico- and Micro-Cellular Networks,

	Channel Assignment Schemes, Resource Management in 4G. Mobile Agent-based Resource Management, Joint Data Rate and Power Management, Dynamic Spectra Sharing in Wireless Networks,
Section-D	***Ad Hoc and Sensor Networks:*** Routing Protocols, Hybrid Routing Protocol, Scalable Routing Strategies, Multipath Routing, Clustering Protocols. Distributed Quos Routing, Sensor Networks Parameters, Sensor Networks Architecture. ***Wireless Network Security****:* IEEE 802.11i Wireless LAN Security, Wireless Application Protocol Overview, Wireless Transport Layer Security, WAP End-to-End Security.

Course Outcomes:

CO1: The students will be able to, Acquire knowledge about Wireless Network Fundamentals. Recognize the various Network Standards and their utility in real world. Acquire knowledge about Routing and Application Layer Protocols.

CO2: Identify wireless network vulnerabilities and apply various security mechanisms to protect networks from security attacks.

Text Books:

1. Rappaport, T.S., Wireless Communications, Pearson Education (20072nded).
2. Zheng, Jun and Jamalipour, Abbas, Wireless Sensor Networks: A Networking Perspective, Wiley-IEEE Press(2009).

Reference Books:

1. Tanenbaum, A.S., Computer Networks, 4th Edition, PrenticeHall(2007).
2. Stallings, W., Network Security Essentials, Prentice Hall (2017)6thEdition.

Name of the Course	**Advanced Computer Networks And Protocols**		
Course Code	**PEC-2005**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- The objective of this course unit is to study the problematic of service integration in TCP/IP networks focusing on protocol design, implementation and performance issues; and to debate the current trends and leading research in the computer networking area.

Section	Course Content
Section-A	***Review of Network Fundamentals:*** Network Systems and the Internet, Network Systems Engineering, Packet Processing, Network Speed, A conventional computer system, Fetch-Store paradigm, Network Interface Card functionality, Onboard Address Recognition, Packet Buffering, Promiscuous Mode, IP Datagram, Fragmentation, Reassembly, Forwarding, TCP Splicing. ***Internetworking:*** Motivation, Concept, Goals, IP addressing, Address Binding with ARP, IP Datagram, Encapsulation IP Fragmentation and Reassembly, ICMP, TCP, UDP concept and datagram protocols, Remote Login, Introduction to Protocol Specification, Validation and Testing.
Section-B	***Network Standards and Standard Organizations:*** Proprietary, Open and De-facto Standards, International Network Standard Organizations, Internet Centralization Registration Authorities, Modern hierarchy of registration authority, RFC categories, The Internet Standardization Process.
Section-C	***TCP/IP Network Interface Layer Protocol:*** TCP/IP Serial Internet Protocols, Point to Point Protocols, PPP core protocols, PPP Feature Protocols, PPP Protocol Frame Formats, ARP and RARP Protocols, IPv4 and IPv6, IP Network Address Translation Protocol, ICMP Protocols and IPv6 Neighbor Discovery Protocol.

Section-D	***Routing and Application Layer Protocols:*** Communication Protocols, Connection Oriented, Connection Less, Working with Network Layer and Transport Layer, Routing Information Protocol (RIP, RIP-2, and Ripping), Border Gateway Protocol, User Datagram protocol, SMTP and FTP protocols, TFTP Protocols, Hypertext Transfer Protocols.

Course Outcomes:

CO1: The students will be able to acquire knowledge about Network Fundamentals.
CO2: Identify Internetworking.
CO3: Recognize the Network Standards and Standard Organizations.
CO4: Interpret the TCP/IP Network Interface Layer Protocol.
CO5: Acquire knowledge about Routing and Application Layer Protocols.

Text Books:

1. Farrel, A., The Internet and Its Protocols - A Comparative Approach, Morgan Kaufmann(2004).
2. Puzmanová, R., Routing and Switching - Time of Convergence, Addison-Wesley(2001).

Reference Books:

1. Tanenbaum, A.S., Computer Networks, 4th Edition, Prentice Hall(2007).
2. Hunt, C., TCP/IP Network Administration, 3rd Edition, O'Reilly Media(2002).
3. Keshav, S., An Engineering Approach to Computer Networking, Addison-Wesley(1997).

Name of the Course	**Optoelectronics Devices And Circuits**		
Course Code	**PEC-2006**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- The main objective of this course is to understand the physics of optoelectronics devices, different types of photon sources and detectors, different modulatorselectrooptic and acousto-optic modulators, electro absorption modulator, basic introduction of holography, Fourier optics and holography and fiber optic sensors.

Section	Course Content
Section-A	***Review of Semiconductor Electronics:*** Overview, Maxwell's Equations and Boundary Conditions, Semiconductor Electronics Equations, Generation and Recombination in Semiconductors, Examples and Applications to Optoelectronic Devices, Semiconductor p-N and n-P Hetero junctions, Semiconductor n-N Hetero junctions and Metal-Semiconductor Junctions.
Section-B	***Photon Sources and Detectors:*** Semiconductor Photon Optical Sources, Light Sources and Transmitters, Light Emitting Diodes, Burros LEDs, Edge Emitting LEDs, LED Analog Transmission, LED Digital Transmission, Introduction to Laser, Black Body Radiations, Boltzmann Statistics, Einstein Coefficient for Absorption and Emission, Semiconductor Laser Diode, Quantum Well Laser, Cleaved Coupled Cavity (C^3) Laser, Index Guide Lasers, Optoelectronics Integrated Circuits-OEICs.
Section-C	***Electro optic and Acousto-optic Modulators:*** Electro optic Effects and Amplitude Modulators, Phase Modulator, Kerr Effect and Kerr Modulators, Electro optic Effects in Waveguide Devices, Scattering of Light by Sound: Raman-Nath and Bragg Diffractions, Coupled-Mode Analysis for Brag Acousto-optic Wave Coupler. ***Electro absorption Modulator:*** General Formulation for Optical Absorption Due to an Electron- Hole Pair, Franz-Keldysh Effect, Exton Effect, Quantum

	Confined Stark Effect (QCSE), Inter band Electro absorption Modulator, Self-Electro optic Effect Devices (SEEDs).
Section-D	***Fourier Optics and Holography:*** Introduction to Fourier Transform, Image Forming Properties of Lenses, Holographic Optical Element (HOE), HOE Fabrication Materials, Vibration and Motion Analysis Holographic Techniques, Hologram Interferometer, Stroboscopic Holography, Modulated Beam Holography. ***Fiber Optic Sensors:*** Introduction to Sensors, Fiber Optic Sensor in Healthcare, Fiber Optic Sensor Basic, Angelology, Gastroenterology, Oncology, Neurology, Neurology, Fiber Bragg Grating for Strain and Temperature Sensors, High Temperature Borehole, Seismometer with Fiber Optic Displacement Sensors.

Course Outcomes:

CO1: The students will be able to, Identify, formulate and solve different optoelectronics devices related problems using efficient technical approaches.

CO2: Familiarization with the basic physics of optoelectronics devices and interpret various optical parameters of the photonic sources and detectors.

CO3: Perform the coupled-mode analysis for wave coupler and learn about the different types of effects in electro optic, electro absorption and acousto-optic modulators.

CO4: Realize the concept of new optical technique i.e. Fourier optics and identify the most suitable materials for holographic optical element fabrication.

CO5: Learn the basics of optical sensors and their applications in medical diagnostics for the benefit of public health

Text Books:

1. S. C. Gupta, “Optoelectronic Devices and Systems,” Second Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Pallab Bhattacharya, “Semiconductor Optoelectronics Devices,” Prentice Hall of India Pvt. Ltd., New Delhi, 2006.

Reference Books:

1. ShunLienChuang,“PhysicsofOptoelectronicDevices,”WileySeriesinPurean dAppliedOptics,John Wiley & Sons.Inc.,1995.
2. J. Singh, “Opto Electronics-As Introduction to materials and Devices,” McGraw-Hill International Edition,1998.
3. B.E.A. Saleh and M.C. Teich, “Fundamental of Photonics, John Wiley and Sons Inc, 2nd Edition,2007.

Name of the Course	**Artificial Intelligence**		
Course Code	**PEC-2007**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- The objective of this subject is to be familiar with the applicability, strengths, and weaknesses of the basic knowledge representation, problem analyzing, and learning methods in solving particular engineering problems.

Section	Course Content
Section-A	***Fundamental Issues:*** Overview of AI problems, Examples of successful recent AI applications, Intelligent behavior, The Turing test, Rational versus non-rational reasoning, Problem characteristics: Fully versus partially observable, Single versus multi-agent, Deterministic versus stochastic, Static versus dynamic, Discrete versus continuous, Nature of agents: Autonomous versus semi-autonomous, Reflexive, Goal-based, and Utility- based, Importance of perception and environmental interactions, Philosophical and ethical issues.
Section-B	***Basic Search Strategies:*** Problem spaces (states, goals and operators), Problem solving by search, Factored representation (factoring state into variables), Uninformed search (breadth-first, depth-first, depth-first with iterative deepening), Heuristics and informed search (hill-climbing, generic best-first, A*), Space and time efficiency of search, Constraint satisfaction (backtracking and local search methods). ***Advanced Search:*** Constructing search trees, Dynamic search space, Combinatorial explosion of search space, Stochastic search: Simulated annealing, Genetic algorithms, Monte-Carlo tree search, Implementation of A* search, Beam search, Minimax Search, Alpha-beta pruning, Expectimax search (MDP-solving) and chance nodes.

Section-C	***Knowledge Representation:*** Propositional and predicate logic, Resolution in predicate logic, Question answering, Theorem proving, Semantic networks, Frames and scripts, conceptual graphs, conceptual dependencies. ***Reasoning under Uncertainty:*** Review of basic probability, Random variables and probability distributions: Axioms of probability, Probabilistic inference, Bayes' Rule, Conditional Independence, Knowledge representations using Bayesian Networks, Exact inference and its complexity, Randomized sampling (Monte Carlo) methods (e.g. Gibbs sampling), Markov Networks, Relational probability models, Hidden Markov Models, Decision Theory Preferences and utility functions, Maximizing expected utility.
Section-D	**Agents:** Definitions of agents, Agent architectures (e.g., reactive, layered, cognitive), Agent theory, Rationality, Game Theory Decision-theoretic agents, Markov decision processes (MDP), Software agents, Personal assistants, and Information access Collaborative agents, Information- gathering agents, Believable agents (synthetic characters, modeling emotions in agents), Learning agents, Multi-agent systems Collaborating agents, Agent teams, Competitive agents (e.g., auctions, voting), Swarm systems and Biologically inspired models ***Expert Systems:*** Architecture of an expert system, existing expert systems: MYCIN, RI. Expert system shells.

Course Outcomes:

CO1: The students will be able to. Analyze the applications of artificial intelligence and categorize various problem domains, uninformed and informed search methods.

CO2: Identify advanced search techniques and algorithms like mini max for game playing. Recognize the importance of probability in knowledge representation for reasoning under uncertainty.

CO3: Describe Bayesian networks and drawing Hidden Markov Models.

CO4: Interpret the architecture for intelligent agents and implement an intelligent agent.

Text Books:

1. Rich E., Artificial Intelligence, Tata McGraw Hills (2009)3rded.
2. George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education Asia (2009)6thed.

Reference Books:

1. Patterson D.W, Introduction to AI and Expert Systems, McGrawHill (1998), 1sted. 4.Shivani Goel, Express Learning- Artificial Intelligence, Pearson Education Asia (2013),1sted.

Name of the Course	**Design For IOT**		
Course Code	**PEC-2008**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:
- Students will be able to understand the concepts of Internet of Things (IoT) and can able to build IoT based applications.

Section	Course Content
Section-A	***Introduction to IoT***: Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models &APIs **IoT& M2M**: Machine to Machine, Difference between IoT and M2M, Software define Network **Sensors and Actuators modules:** Concept, layout, working and applications of different sensors and actuators: temperature sensor, motion sensor LDR sensors, IR sensor, Ultrasonic sensor, Relay etc.
Section-B	***Embedded Systems for IoT:*** Introduction to Arduino Programming, Arduino interfacing with sensors and actuators, IoTbased actuator operation using Arduino, Introduction to R-pi and its Programming, R-pi hardware interfacing and applications, Smartphone interfacing with R-pi, Wi-Fi module interfacing with R-pi and associated applications.
Section-C	***Network and Communication Protocol:*** Wireless medium access issues, MAC protocol survey, Constrained Application Protocol (CoAP), Message Queue Telemetry Transport Protocol (MQTT), Sensor deployment & Node discovery,Data handling and analytics, Cloud platform for IoTs,.
Section-D	***Developing IoT based Systems***: Experiments with Arduino Hardware and sensor interfacing procedures. Automatic lighting control using IoT, home automation, connected health, smart farming, industry applications, connected vehicles, smart city, developing sensor based application through embedded system platform. Introduction to Python, Implementing IoT concepts with

	python ***Challenges in IoT***: Design challenges, Development challenges, Security challenges, other challenges.

Course Outcomes:

CO1: On successful completion of the course, the student will be able to: Recognize the concepts of Internet of Things.

CO2: Demonstrate the interfacing of different sensors and actuators modules with embedded systems.

CO3: Analyze basic protocols in wireless sensor network.

CO4: Design IoT applications in different domain and be able to analyze their performance.

CO5: Develop and implement IoT applications using Python.

Text Books:

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: AHands-On Approach"
2. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things" John Wiley (2014)1sted.

Reference Books:

1. Hanes David ,Salgueiro Gonzalo, Grossetete Patrick, Barton Rob, Henry Jerome," IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things", Pearson(2016).
2. Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley &Sons, Ltd(2011).

<table>
<tr><td>Name of the Course</td><td colspan="3">Computational Electro magnetic</td></tr>
<tr><td>Course Code</td><td>PEC-2009</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hr Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.</td></tr>
<tr><td colspan="4">Course Objectives:
❖ The objective of course is to develop the skills required to solve problems related to electrostatics, magneto statics, microwaves and optical waves using computational methods.</td></tr>
</table>

<table>
<tr><th>Section</th><th>Course Content</th></tr>
<tr><td>Section-A</td><td>Review of Basic Electromagnetic: Electrostatics, Magneto statics, Wave equations, TE, TM and Hybrid modes, Guided wave structures, Metallic waveguides, Dielectric waveguides, Radiating structures Applications of electromagnetic, Historical development of Computational.
Numerical Methods: ODE solvers, Euler, Runge-Kutta, Boundary conditions, Propagation of errors, Survey of numerical packages.</td></tr>
<tr><td>Section-B</td><td>Finite Difference Time Domain Method: An overview of finite differences time domain method, the 1D, 2D & 3D FDTD algorithm, Obtaining wideband data using the FDTD, Numerical dispersion in FDTD simulations, The PML absorbing boundary condition, Commercial implementations.</td></tr>
<tr><td>Section-C</td><td>Method Of Moments: (MoM): An overview of Method of Moment (MoM), Thin-wire electrodynamics and the MoM more on basis functions, the method of weighted residuals.</td></tr>
<tr><td>Section-D</td><td>Finite Element Method (FEM): Introduction of Finite element method, Variation land Galerkin weighted residual formulations: the Laplace equation, Simplex coordinates, high- frequency variation functional, Spurious modes, Vector (edge) elements, Application to wave guide Eigen value analysis, The three- dimensional Whitney element, The time domain FEM
Application: Deterministic 3D application: waveguide obstacle analysis, Application to two- waveguide discontinuity problems, Hybrid finite</td></tr>
</table>

	element/method of moment's formulations, an application of the FEM/MoM hybrid – GSM base stations.

Course Outcomes:

CO1: The students will be able to. Acquire knowledge about history and application computational electromagnetic.

CO2: Acquire knowledge about different computational electromagnetic techniques.

CO3: Solve the electromagnetic problem using computational techniques

Text Books:

1. Balanis, C., Antennas, John Wiley and sons (2007)3rdedition.
2. David B. Davidson, Computational Electromagnetic for RF and Microwave Engineering, Cambridge University Press2005.

Reference Books:

1. Dennis M. Sullivan, Electromagnetic simulation using the FDTD method

Name of the Course	**Machine and Deep Learning**		
Course Code	**PEC-2010**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:

- ❖ To understand various key paradigms for machine learning approaches.
- ❖ To familiarize with the mathematical and statistical techniques used in machine learning.
- ❖ To understand and differentiate among various machine learning techniques.
- ❖ Provide technical details about various recent algorithms and software platforms related to Machine Learning with specific focus on Deep Learning.

Section	Course Content
Section-A	***Introduction:*** Definitions, Datasets for Machine Learning, Different Paradigms of Machine Learning, Data Normalization, Hypothesis Evaluation, VC-Dimensions and Distribution, Bias-Variance Tradeoff, Regression (Linear) Bayes Decision Theory: Bayes decision rule, Minimum error rate classification, Normal density and discriminate functions
Section-B	***Parameter Estimation:*** Maximum Likelihood and Bayesian Parameter Estimation. Discriminative Methods: Distance-based methods, Linear Discriminate Functions, Decision Tree, Random Decision Forest and Boosting Feature Selection and Dimensionality Reduction: PCA, LDA, ICA, SFFS, SBFS.
Section-C	***Clustering:*** k-means clustering, Gaussian Mixture Modeling, EM-algorithm Kernel Machines: Kernel Tricks, SVMs (primal and dual forms), K-SVR, K-PCA Artificial Neural Networks: MLP, Backdrop, and RBF-Net. Foundations of Deep Learning: DNN, CNN, Auto encoders
Section-D	***Deep Networks:*** CNN, RNN, LSTM, Attention layers, Applications (8 lectures) Techniques to improve deep networks: DNN Optimization, Regularization, Auto

	ML. Representation Learning: Unsupervised pre-training, transfer learning, and domain adaptation, distributed representation, discovering underlying causes

Course Outcomes:

The students are expected to have the ability to:

CO1: To formulate a machine learning problem

CO2: Select an appropriate pattern analysis tool for analyzing data in a given feature space.

CO3: Apply pattern recognition and machine learning techniques such as classification and feature selection to practical applications and detect patterns in the data

Text Books:

1. Shalev-Shwartz,S., Ben-David,S., (2014), Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press
2. R. O. Duda, P. E. Hart, D. G. Stork (2000), Pattern Classification, Wiley-Blackwell, 2nd Edition.
3. Goodfellow,I., Bengio.,Y., and Courville,A., (2016), Deep Learning, The MIT Press

Reference Books:

1. Mitchell Tom (1997). Machine Learning, Tata McGraw-Hill
2. C. M. BISHOP (2006), Pattern Recognition and Machine Learning, Springer-Verlag New York, 1st Edition.
3. Charniak, E. (2019), Introduction to deep learning, The MIT Press.

Name of the Course	**Flexible and Printable Electronics Technology**		
Course Code	**PEC-2011**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:
The course will provide an introductory survey of the technology and applications for printed and flexible electronics.

- ❖ Acquire and develop basic concepts and understanding of flexible and printable electronics.
- ❖ Develop an understanding of the relationship between printing techniques, device performance, and target applications for electronics on soft matter.
- ❖ Understand the basic concepts for integration of devices on flexible platforms and the advantages and disadvantages of emerging technology used for future devices.
- ❖ Obtain a fundamental understanding Future Trends of Flexible/Printable electronics technology, and the pathways for commercialization of emerging materials, processes, and tools for printed and flexible electronic systems.

Section	Course Content
Section-A	***Introduction:*** Introduction to Flexible & Printable electronics- Historical background - Materials, devices, systems, applications - Fabrication techniques - Unique aspects, status in the field and trends,Stretchable electronics, Wearable Electronics, Potential level of printed electronics in the industry, area of applications of printed electronics.
Section-B	***Printing And Fabrication Technology***: Basics and fundamentals sheet to sheet and roll to roll printing techniques- imprint lithography, spray pyrolysis, multilayer patterning, Functional inks–Conductive, semi-conductive, insulating inks, and their characterization, different materials and their properties in printed electronics, Various substrates and their types.

Section-C	***Flexible and printable devices:*** Organic devices on flexible substrate, Sensors and biosensors, RFID, Antenna, FET etc., Examples of flexible physical, chemical and optical sensors, Actuators, Examples of flexible optical and thermal actuators, Displays, sensor arrays, memory devices, MEMS, lab-on-a-chip, and photovoltaic
Section-D	***Future Trends Of Flexible/Printable Electronics Technology: A***dvanced technologies used in printed electronics production, Energy harvesting and storage components - Energy harvesters - Principles and fundamentals - Examples of flexible energy harvesters - Storage components - Principles and fundamentals, barrier materials, Examples of flexible super-capacitors and batteries, Further processing components - Interconnections, memories, opportunities, obstacles and future trends printed electronics.

Course Outcomes:

CO1: An ability to apply knowledge of mathematics, science, and engineering
CO2: Ability to design and conduct experiments, as well as to analyze and interpret data.
CO3: An ability to design a system, component, or process to meet desired needs.
CO4: An ability to function on multi-disciplinary teams.
CO5: Ability to identify, formulate, and solve engineering problem

Text Books:

1. "Large Area and Flexible Electronics", M. Caironi and Y.Y. Noh, WILEY-VCH, 2015.- "Flexible Electronics: Materials and Applications", W. S. Wong, A. Salleo, Springer, 2009.
2. "Organic and Printed Electronics: Fundamentals and Applications", G. Nisato, D. Lupo, S. Ganz, CRC Press, 2016.
3. "Organic Flexible Electronics: Fundamentals, Devices, and Applications", P. Coseddu and M. Caironi, Elsevier, 2020.
4. ChristophBrabec, UllrichScherf, Vladimir Dyakonov (Editors), Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies, Wiley-VCH, 2014.

Reference Books:

1. **F**rederik C. Krebs, Stability and Degradation of Organic and Polymer Solar Cells, Wiley, 2012.
2. Hagen Klauk (Editor), Organic Electronics: Materials, Manufacturing, and Applications, Wiley-VCH, 2006.
3. Organic Electronics II: More Materials and Applications, Wiley-VCH, 2012.
4. Franky So (Editor), Organic Electronics: Materials, Processing, Devices and Applications, CRC Press, 2009.
5. Mario Pagliaro, Flexible Solar Cells, Wiley-VCH, 2008

Name of the Course	**Advanced Antenna Theory and Design**

Course Code	PEC-2012	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.

Course Objectives:
- The course objective is to understand the theory and fundamentals of antenna design.
- The course helps the students to learn key aspects of practical antenna design. A broad range of antennas such as dipole, loop, micro strip patch, horn, etc are studied during the course.

Section	Course Content
Section-A	***Fundamental Concepts:*** Radiation pattern, near- and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Fries transmission equation, radiation integrals and auxiliary potential functions. Radiation from Wires and Loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop
Section-B	***Aperture Antennas:*** Huygens' Principle, radiation from rectangular and circular apertures, design considerations, Babine's principle, and Fourier transform method in aperture antenna theory. Horn and Reflector Antennas: Radiation from sect oral and pyramidal horns, design concepts, prime-focus parabolic reflector and cases grain antennas.
Section-C	***Micro strip Antennas:*** Basic characteristics, feeding methods, methods of analysis, design of rectangular and circular patch antennas
Section-D	***Antenna Arrays:*** Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays, synthesis of antenna arrays using Schelkun off polynomial method, Fourier transform method, and Woodward-Lawson method.

Course Outcomes:

CO1: By the end of this course students will have good understanding of antenna fundamentals and the knowhow of designing various kinds of antennas such as dipole, loop, micrsotrip patch antennas and arrays.

CO2: Students will also learn industry standard simulation software Anasys HFSS.

Text Books:

1. 1.Balanis, C.A., "Antenna Theory and Design", 3rd Ed., John Wiley & Sons. 2005
2. Jordan, E.C. and Balmain, K.G., "Electromagnetic Waves and Radiating Systems", 2nd Ed., Prentice-Hall of India. 1993
3. Stutzman, W.L. and Thiele, H.A., "Antenna Theory and Design", 2nd Ed., John Wiley & Sons. 1998

Reference Books:

1. Elliot, R.S., "Antenna Theory and Design", Revised edition, WileyIEEE Press. 2003
2. Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A., "Microstrip Antenna Design Handbook", Artech House.

<table>
<tr><td>Name of the Course</td><td colspan="3">Nano-photonics</td></tr>
<tr><td>Course Code</td><td>PEC-2013</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hr Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
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<tr><td colspan="4">For Paper Setters:
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<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculatoris allowed to use in examinations.</td></tr>
<tr><td colspan="4">Course Objectives:
❖ The course is aimed to: Expose them to the emerging area of nano photonic and the phenomena involved in such devices.
❖ Provide deep understandings of light – matter interaction at Nano scale.
❖ Study different types of nano photonic crystal based devices and systems.</td></tr>
</table>

Section	Course Content
Section-A	***Review Of Electro Magnetics:*** Maxwell equations Wave optics Electromagnetic radiations and evanescent waves Quantum mechanics and band theory of solids Particle wave duality Schrodinger equation and electron states Energy bands in solids Optical properties of bulk materials linear optical properties Nonlinear optical effects.
Section-B	***Conventional Photonics:*** Fresnel Coefficients, Total internal reflection, Evanescent waves, Dielectric waveguides and cavities, Group velocity and density of states. Surface Plasmon Polaritons. Optical properties of noble metals, Nonlocal effects, Surface plasmonpolaritons waveguides, Light focusing.Localized Surface Plasmons. Near-field enhancement and cross section.Simple geometries in the quasi-static limit.Quantum emitters.Purcell effect.
Section-C	***Current Topics On Nano Photonics:*** Photonic Crystals, Meta materials, Super-resolution imaging, Plasmonics in 2D materials, Super-planckianradiative heat transfer.
Section-D	***Silicon Photonics:*** Optical properties of silicon, Silicon-based photonic components and devices, Photonic crystals, 1D, 2D, and 3D photonic crystals

	Photonic crystal fibers Photonic Meta materials Electric, magnetic, negative-index, and chiral Meta materials Applications of optical meta materials

Course Outcomes:

At the end of course student will be able to

CO1: Gain the foundations of nano photonics.

CO2: Understand the mathematical synthesis of Maxwell equations for Photonic systems.

CO3: Acquire the understanding and importance of confinement and propagation.

CO4: Obtain the knowledge of 1-D, 2-D and 3-D Photonic Crystals.

CO5: Gain the design and scope of nano-photonics applications.

CO6: Learn the foundation of plasmonics.

Text Books:

1. L. Novotny and B. Hecht, Principles of Nano-Optics. Cambridge University Press, 2nd edition, 2012.
2. J. D. Jackson, Classical Electrodynamics. Wiley, 3rd edition, 1999.
3. S. A. Maier, Plasmonics: Fundamentals and Applications. Springer, 1st edition, 2007.

Reference Books:

1. J. D. Joannopoulos, S. G. Johnson.
2. J. N. Winn, and R. D. Meade.
3. Photonic Crystals: Molding the Flow of Light.
4. Princeton University Press, 2nd edition, 2008.