M. Sc. Tech (Photonics)

One of the greatest scientific discoveries of the twentieth century that has led to technological advancement touching all aspects of human life is the LASER. Applications of lasers range from medical applications, communications, and industrial applications to military applications. An understanding of laser technology is essential for an engineer working in many of the present-day cutting-edge technologies. The aim of this program is to train the students in the field of lasers, fiber optics, electro-optics, and photonics that would enable them to meet the challenges in this rapidly developing field. The syllabus has been designed as per the guidelines of NEP 2020.

Stakeholders:

(i) Sponsored candidates from Army, Navy, Air Force, DRDO Laboratories, Public Sector Undertakings, and other departments

(ii) Graduates in the relevant field of science/technology from recognized Universities across the country.

Eligibility for Students:

The candidate should possess Bachelor's degree or equivalent in Physics, Applied Physics, Engineering Physics, Electronic Science, Photonics, Optics, Material Science, Instrumentation Science or any equivalent branch

OR

B. Tech. (Any discipline)

Organization: The M. Sc. programme is of four-semester duration. In each of the first three semesters there are six theory courses and one laboratory course. There will be three continuous evaluation examinations and a final semester examination for every course. At the end of the final semester, the student submits a dissertation and makes a presentation about the work carried out by him/her on the project, which is evaluated by the Internal and External examiners. Course syllabus is updated periodically to keep pace with the contemporary technological advancement.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: The M. Sc. in Photonics programme aims at developing skilled human resources in the field of Optics, lasers, Electro-optics and overall Photonics. It will ensure the understanding of applied optics, physics and engineering laser technology, fiber optics, semiconductor photonic devices, laser systems and its various applications, catering to the emerging multidisciplinary problems faced by defence industry and civilization.

PEO2: With a focus on the DRDO requirements, the students will be trained to use their knowledge for the benefit of society and made aware of their social duty. This will enable them to pursue career in research, academics and industry.

PEO3: At the end of the programme the officer or student should be able to undertake state of the art R&D in lasers and electro-optic systems and competitively work towards development of the latest technology in line with national programmes like Make in India.

PROGRAMME OUTCOMES (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program

PO4: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO5: Having a clear understanding of professional and ethical responsibility

PO6: Having a good cognitive load management skill related to project management and finance

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Sc. (Photonics) programme, graduates will be able to

PSO1: The M. Sc. in Photonics aims at developing a skilled knowledgeable Human task force in the field of Photonics serving the needs of the Defence Research and Development Organization & Tri – services (Army, Navy & Air force), Coast Guard, DGQA, DQA, Defence Public Sector units, in addition to the civilians in general. After completing M. Sc. course, the students develop an ability to carry out independent research in the area of optical devices.

PSO2: The dissertation work of the M. Sc. students leads to publications in high impact international journals which trains them in technical documentation and report writing.

PSO3: The goal of the M. Sc. in Photonics course is to generate highly competent human resources in the areas of laser development, electro-optic systems, fibre optics, applied optics, and computational photonics.

Credit Structure (As per NEP 2020)

1 credit = 15 clock hours of teaching or tutorial

1 credit = 30 clock hours of practical

SEMESTER I

Sl. No.	Course Code	Course	Credit distrubution			Total Credits
			L	T	P	
1	AP501	Quantum Mechanics	3	1		4
2	AP502	Introduction to Optics & Photonics	3		1	4
3	AP 503	Introduction to Lasers	3		1	4
4	RM 501	Research Methodology	3	1		4
5	AP 505	Basic Photonics Laboratory	0		2	2
6		Elective 1	3	1		4
		Total	**15**	**03**	**4**	**22**

Options for Elective 1:

Choose Any one						
1	MS 505	Computational Mathematics	3	1		4
2	AM 607	Mathematics of Engineers	3	1		4

SEMESTER II

Sl. No.	Course Code	Course	Credit distribution			Total Credits
			L	T	P	
1	AP506	Electronic devices and circuits	3		1	4
2	AP507	Solid State Physics	3	1		4
3	OJT/FP	On-Job Training/Field Project				**4**
4	AP 509	Nanophotonics	3	1		4
5	AP 510	Electronics and Photonics Laboratory	0		2	2
6		Elective 2	3	1		4
		Total	**12**	**03**	**03**	**22**

*** To be completed during the summer vacation (120 Hrs)**

Options for Elective 2:

Choose Any one						
1	AP 631	Laser Applications	3	1		4
2	**AP 508**	Computational Photonics	3	1		4

SEMESTER III

Sl. No.	Course Code	Course	Credit distribution			Total Credits
			L	T	P	
1	AP 624	Semiconductor Photonic devices	3	1		4
2	AP623	Introduction to Fiber Optics	3	1		4
3	AP 512	Advanced Photonics Laboratory	0		4	4
4	AP 513	Introduction to Programming	0		2	2
5	RP 541	Research Project – 1				**4**
6		Elective 3	3	1		4
		Total	**08**	**02**	**08**	**22**

Options for Elective 3:

Choose Any one						
1	EE 602	Digital Signal processing	3	3		4
2	EE 624	Digital System Design using FPGA	2		2	4
3	AP 514	IntrodutionotBiophtonoics	3		1	4

SEMESTER IV

Sl. No.	Course Code	Course	Contact Hours /week			Credits
			L	T	P	
1	AP 608	Machine learning techniques for sensor data analytics	3	1		4
2	AP-642	Tera Hertz Devices and Applications	3	1		4
3	AP 643	Free Space Optical Communication	3	1		4
4	RP 542	Research Project – II				**6**
5		Elective 4	3	1		4
		Total	**12**	**4**		**22**

Options for Elective 4:

Choose Any one						
1	QT 622	Nonlinear and Quantum Optics	3	1		4
2		NPTEL/MOOC course	3	1		4

SEMESTER V

Sl. No.	Course Code	Course	Total Credits
1	AP-551	Major Project Phase - I	20
		Total	**20**

SEMESTER VI

Sl. No.	Course Code	Course	Total Credits
1	AP-552	Major Project Phase - II	20
		Total	**20**

SEMESTER VI

UGC recommended courses (Additional 10 credits)

(to be completed by the student/candidate before the completion of the program)

Cyber Security/Information security - 4 credits
Human Rights-I - 1 credit
Human Rights-II - 1 credit
Introduction to Indian Constitution - 2 credits
Skill Development Courses - 2 credits

SemsterI Course details

AP501 – Quantum Mechanics

Course Outcomes:

CO-1	Understand the basic concepts of quantum mechanics Physics
CO-2	Interpret the physical meaning of formulation in quantum mechanics
CO-3	Examine different 1D problems in quantum mechanics
CO-4	Illustrate the implementation to 1 electron atoms

CO-5	Explain Quantum mechanics to Lasers

Syllabus:

Units	Syllabus Details	Hrs
Unit I	Historical Origin of Quantum mechanics: Thermal radiation, Plank's postulates, Black body radiation, stationary states, correspondence principle, Bohr Atom, shortcomings of old quantum theory.	**9**
Unit II	The Schrödinger equation, Statistical interpretation, probability, normalization, momentum, The uncertainty principle	**6**
Unit III	Time Independent Schrödinger: stationary states, infinite square well, harmonic oscillator, free particle, delta function potential, finite square well	**9**
Unit IV	Formalism: Hilbert's space, observables, eigen function of Hermitian operator, statistical interpretation, Dirac notation	**6**
Unit V	One electron atoms: solution of Schrödinger equation in 3D, eigen values, quantum numbers, and degeneracy, orbital angular	8
Unit VI	Quantum statistics: indistinguishability and quantum statistics, quantum distribution functions, Boltzmann distribution as an approximation to quantum distributions, Introduction to Quantum Optics, Coherent States	**7**

References Textbooks:

1. Quantum Mechanics, John Powell, Bernd Crasemann, Narosa Publishing House
2. Quantum Mechanics, Leonard Schiff, Mc-Graw Hill Book Company
3. Quantum Physics of Atoms, molecules, solids nuclei and particles by Robert Eisberg and Robert Resnick Wiley publishing
4. Introduction to Quantum Mechanics by David Griffiths Pearson Publishing
5. Quantum Mechanics by B H Bransden and C J Joachain Pearson Publishing

AP-502 – Introduction to Optics and Photonics

Course Outcomes:

CO-1 :	Interpret the concepts of optical electronics
CO-2 :	Analyze the working principle of ME Theory, EO, MO and AO effects
CO-3 :	Examine the working mechanism of different types of Optical components, EO, MO and AO effects
CO-4 :	Illustrate the practical use of Optical components, EO, MO and AO effects
CO-5 :	Summarize different applications of optical electronics devices

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Fundamentals of Photonics and Optics:** Wave equation, Plane waves, Applications of photonics, Reflection and Refraction of plane waves, Fresnel Equations, Wave propagation in different mediums, propagation of Electromagnetic waves in Uniaxial and biaxial crystals, the dielectric constant tensor and the 'index ellipsoid'	**9**
Unit II:	**Polarisation of light and Basic optical components:** Electromagnetic theory of light, Dielectric media, Monochromatic EM waves, Absorption and dispersion, Polarisation of light, Jones Calculus, Poincare sphere. Polarisers, Quarter, Half, and Full waveplates, Beam splitters: polarizing and non-polarizing, wavelength filters, dichroic mirrors, Lenses.	**10**
Unit III	**Electro-optics:** Basic principles: Pockel and Kerr effects, Electro-optic	**9**

	devices: modulators, switches, and scanners, E.O. effect in liquid crystals; LCDs and SLMs, Applications.	
Unit IV	**Acousto-optics:** Strain waves in solids and liquids, the strain-optic tensor; theory of Raman-Nath and Bragg diffraction; small-angle and large-angle Bragg diffraction. Accousto-optic devices: Modulators, deflectors, scanners, interconnections, and acoustooptictunable filters.	**9**
Unit V	**Magneto-optics**: Principles, Faraday effect, Gyrotropic permittivity, Kerr rotation and Kerr ellipticity, Applications.	8

References Textbooks:

1. A. K. Ghatak& K. Thyagarajan, Optical Electronics, Cambridge University Press,1989. References
2. A. Yariv, P. Yeh, Photonics: Optical Electronics in Modern Communications, The Oxford Series in Electrical and Computer Engineering, 2006.
3. B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007)
4. S. Sugano, N. Kojima (Eds.), Magneto-Optics, Springer Series in Solid-State Sciences, Vol. 128, 2000.
5. O. Svelto, Principles of Lasers, Plenum Press, New York, 1998.
6. P. W. Milonni and J. H. Eberly, Lasers, Willey Inter Science, 1988.
7. A. K. Ghatak and K. Thyagarajan, Lasers: Theory & Applications, Macmillan India Limited, 2003.

AP-503 – Introduction to Lasers

Course Outcomes:

CO-1 :	Interpret the concepts of laser technology
CO-2 :	Analyze the working principle of lasers
CO-3 :	Examine the laser radiation beams
CO-4 :	Illustrate and construct the practical laser systems
CO-5 :	Summarize different types of laser systems and its working principals

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Light-matter interaction:** Interaction of radiation with atomic systems, Einstein's coefficients, spontaneous emission, stimulated emission, Linewidth of the laser	10
Unit II:	**Lasers Oscillation**: Theory of laser oscillation; Threshold condition, Rate equation, Optical amplification and feedback, Condition for laser oscillation, Characteristics of laser output power, Pumping techniques.	10
Unit III	**Laser Resonators and Gaussian Beams**: The Ray Matrix, Resonator Stability, Paraxial Wave Equation, Gaussian Beams, ABCD Law for Gaussian Beams, Gaussian Beam Modes, Hermite–Gaussian and Laguerre–Gaussian Beams, Resonators for He–Ne Lasers, Diffraction, Diffraction Theory of Resonators, Beam Quality.	10
Unit IV	**Laser Systems 1:** Solid-state lasers, Gas lasers,	8
Unit V	**Laser Systems 2:**Fiber laser and amplifiers	7

Reference Book:

1. A. K. Ghatak and K. Thyagarajan, Lasers: Theory & Applications, Macmillan India Limited, 2003.
2. O. Svelto, Principles of Lasers, Plenum Press, New York, 1998.
3. P. W. Milonni and J. H. Eberly, Lasers, Willey Inter Science, 1988
4. B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007)
5. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1995).

AP-505 –Basic PhotonicsLaboratory

Course Outcomes:

CO-1 :	To understand basic electronics
CO-2 :	To interprete characteristics of the devices
CO-3 :	Examine the working of basic electronic components
CO-4 :	Illustrate working of optical components
CO-5 :	Explain difference in diode and Laser characteristics

Syllabus:

Syllabus Details	**Hrs**
Photonics 1. Measurement of Refractive index using Michelson Interferometer 2. Determination of the Electrical and Optical Characteristics of LED and Laser diode. 3. Experiment on Laser beam cleaning by Spatial Filtering 4. Beam Collimation with different telescopic arrangement 5. Measurement of diameter of thin wire using the laser light diffraction method. 6. Young's Single-slit and Double Slit experiment 7. Determine the lines per inch of a Transmission diffraction grating by its dispersive angles. 8. Detection of polarisation states using polarisation components like polarizers, waveplates etc. 9. Analysis of various light source spectra using OSA. 10. Determination of Numerical Aperture and V Number of single mode & multimode fiber. 11. Macro and Microbending loss in optical fibers and its application 12. Measurement of Photodiode characteristics 13. Study of Fraunhofer diffraction pattern of a rectangular and circular aperture. 14. Finding the Verdot's constant by Faraday Effect 15. OptiSystem training module for Optical System Designing	60

MS-505- Computational Mathematics

Course Outcomes:

CO-1:	Understand the basics of Linear Algebra
CO-2:	Recognize the principles of Multivariable calculus

CO-3:	Apply the principles of Differential and Integral calculus
CO-4:	Interpret the concepts of Scientific Computations
CO-5:	Implementing numerical methods to solve differential equations

Syllabus:

Units	**Syllabus Details**	**Hrs**
Unit I	Linear Algebra: Algebra of real matrices: Determinant, inverse and rank of a matrix; System of linear equations (conditions for unique solution, no solution and infinite number of solutions); Eigenvalues and eigenvectors of matrices; Properties of eigenvalues and eigenvectors of symmetric matrices, diagonalization of matrices; Cayley-Hamilton Theorem.	**9**
Unit II	Calculus of single and multiple variables: Limit, Continuity and differentiability; Maxima and minima – Necessary and sufficient conditions; Partial derivatives; Total derivative	**9**
Unit III	Vector Calculus: Vector Fields; Gradient, divergence and curl; Line integrals, and Green's theorem; Divergence theorem; Physical interpretation of mathematical operations	**9**
Unit IV	Scientific Computing: Concepts of discretization in space/time, implicit, explicit; Taylor's series; Solution to ODEs	**9**
Unit V	Numerical Solution of Differential Equations: Classification of second order linear partial differential equations; Method of separation of variables: One dimensional heat equation and two-dimensional Laplace equation.	**9**

Text Book(s)

- *Advanced engineering mathematics: Kreyszig; Wiley.*
- *Advanced engineering mathematics: Jain/Iyenger; Narosa*

Reference Book(s)

- *Advanced engineering mathematics: Peter V. O'Neil Cengage Learning*
- *Advanced engineering mathematics: Alan Jeffery; Academic Press*
- *Calculus and analytic geometry: Thomas/Finney; Narosa*
- *Numerical methods for Engineers: Steven C. Chapra and Paymond P. Canale*

Semster II Course details

AP-506 – ElectronicDevices and Circuits

Syllabus:

Units	**Syllabus Details**	**Hrs**
Unit I:	Basics of semiconductor and Introduction to Diodes: The energy band theory of crystals, Intrinsic and Extrinsic semiconductors. P-N Junction diode as a Rectifier, Photo-Diode, Filters using Diode, Clipping & clamping circuits, LED, Zener diode	8
Unit II	Transistors and Oscillators: Basics of Transistor, Transistor characteristics and applications, basics of oscillators and multivibrators (IC555 as timer).	10
Unit III	Field Effect Transistor: Structure and working of: JFET, I-V characteristics and parameters (Pinch off voltage, trans conductance, drain resistance, amplification factor); MOSFET (construction and application only) Applications: FET as Voltage Variable resistance (VVR), switch, memory cell, DRAM	10
UNIT	OPAMPS & Multivibrators :	10

IV:	Idea op-amplifier characteristics, Block diagram, Basic Inverting & non inverting amplifier, Basics of oscillator, Basics of Timer IC 555 as astable multivibrator.	
UNIT V:	Sequential circuits and Counters: RS, Clocked RS, JK, Master Slave JK, D Flip flop, Counter-synchronous, asynchronous, up-down counter, modulo-N counter, Decade counter (IC 7490); shift register (IC 7495), ring counter	7

Reference Books:

1. Millman's Integrated Electronics - Analog and Digital Circuit and Systems | 2nd Editionby Jacob Millman, Christos Halkias, Chetan Parikh
2. Electronic Principles | 7th Edition by Albert Malvino , David J. Bates
3. Roberts L Boylestad & Louis Nashelsky Electronic Devices Circuit Theory

AP-507 – Solid State Physics

Course Outcomes:

CO-1 :	Understand the basic concepts of Solid State Physics
CO-2 :	Interpret the physical meaning of formulation in Condensed Mateer
CO-3 :	Examine different Structure related properties
CO-4 :	Study the Electronic and magnetic properties of solids
CO-5 :	Develop skills to solve physics problems

Syllabus:

Units	Syllabus Details	Hrs
Unit I	**Crystal Structure and Diffraction:** Real lattices, packing fraction, reciprocal lattices, Brillouin zones. Diffraction by crystals - Ewald sphere construction, Bragg condition in k-space. Geometric structure factor and atomic form factor. Point defects, line defects and dislocations.	8
Unit II	**Lattice Dynamics:** Vibrations of crystals with mono-atomic and diatomic basis. Brillouin zones. Optical modes and acoustic modes. Quantization of elastic waves. Phonon momentum. Neutron scattering by phonons. Phonon heat capacity. Phonon density of states. Einstein and Debye theories , thermal conductivity.	10
Unit III	**Electronic Band Structure in Crystals**: Drude theory of metals. Quantum free electron model of metals (Sommerfeld model). Nearly free electron theory. Brillouin zones. Electron effective mass. Density of states and band gap. Kronig-Penney model. Bloch theorem. Crystal momentum. Qualitative distinction between semiconductors and metals. Fermi surface of metals. Hall effect.	10
Unit IV	**Dielectric and Magnetic Properties of Solids:** Macroscopic electric field and local electric field in solids. Polarizability and dielectric constant. Claussius-Mossotti relation. Dielectric-Ferroelectric phase transition. Landau theory. Piezoelectricity.	10
Unit V	**Magnetism** – Diamagnetism, Langevin equation. Pauli paramagnetism in metals. Paramagnetism –Curie law. Ferromagnetism. Quantum mechanical nature of ferromagnetic interaction. Anti-ferromagnetic and ferromagnetic	7

	order.	

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel (John Wiley and Sons.).
2. Solid State Physics, A. J. Dekkar (Prentice Hall).
3. Solid State Physics, N. W. Ashcroft and N. D. Mermin (CBS Publishing Asia Ltd.).

AP-509 – Nanophotonics

Course Outcomes:

CO-1	Familiarization to the concept of Metamaterials
CO-2	Illustration of Optical Properties in Metamaterials
CO-3	Examine Surface Plasmon Resonance
CO-4	Analyze Photonic Bandgap Crystals in different dimensions
CO-5	Understanding the Importance of Silicon Photonics and Its Applications

Syllabus:

Units Divisions	Syllabus Details	Hours
Unit I	Basics of Nanophotonics: Photons and electrons, Quantum confinement effects, 2D, 1D, 0D structures, their growth and properties	**9**
Unit II:	**Metamaterials:** Definition of Metamaterials (MTMs) and Left-Handed (LH) MTMs, **Fundamentals of LH MTMs** Left-Handedness from Maxwell's Equations	**9**
Unit III:	**Metamaterial in Optics:** Optical Properties of Metal-Dielectric Composites, Optical Magnetism, Negative-refractive Index, Perfect lens and Cloaking objects.	**9**
Unit IV	**Surface Plasmon Resonance:** Evanescent waves, Surface Plasmon dispersion equations, resonance, excitation od surface plsmons, surface Plasmon properties, SPR spectroscopy	**9**
Unit V	**Photonic band gap crystals:** Photonics Band-Gap: Introduction to Photonics crystal, Photonic Band Structures, One dimensional, Photonic crystal: Origin of Photonics Band Gap, Size of the band gap, Evanescent Modes in Photonics Band gaps, Two-dimensional Photonic crystal: Two-dimensional Bloch States, Square Lattices (Dielectric Columns and Veins), Three-dimensional Photonic crystal: Three-dimensional lattices,	**11**

References Textbooks:

1. Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications, Christophe Caloz,Tatsuo Itoh, John Wiley and Sons,2006
2. Optical Metamaterials, Fundamentals and Applications, Wenshan Cai Vladimir Shalaev, Springer, 2010.
3. John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn, and Robert D. Meade,Photonic Crystal: Molding Light Flow of Light, Princeton University Press, 2008.
4. Graham T. Reed and Andrew P. Knights, Silicon Photonics: An Introduction, JohnWiley and Sons Ltd, 2004
5. Metamaterials: Physics and Engineering Explorations, Nader Engheta Richard W. Ziolkowski, Wiley and Sons,2006

6. Negative-Refraction Metamaterials Fundamental Principles and Applications, G. I. Eleftheriades K. G. Balmain,Wiley and Sons,2005

AP-510 – Electronics and Photonics Laboratory

Course Outcomes:

CO-1 :	Understand basic logic circuits
CO-2 :	Analyze the working of A/D and D/A convertors
CO-3 :	Illustrate the working Holography
CO-4 :	Examine the losses in fiber optical communication
CO-5 :	Interprete the working of fiber lasers

Syllabus:

Syllabus Details	Hrs
Electronics: 1. To study the I-V Characteristics of Diodes (Simple and Zener Diode) 2. To study the I-V Characteristics of Transistors in CB, CE, CC modes (NPN and PNP Transistors) 3. To study the I-V Characteristics of MOSFETs 4. To study the Half, Full, and Bridge rectifier 5. To study the Voltage and Current regulation with a fixed load 6. To study the Clipping and clamping Circuit 7. To study the Characteristics of 741 OPAMPs 8. To analyze the inverting and non-inverting amplifier 9. To Design Active filters	60 hrs
Photonics: 1. Beam Width, Divergence, and M^2 measurement of He-Ne/Diode Laser with and without collimation lens. 2. Fiber optic link design 3. Measurement of attenuation and dispersion in optical fibers 4. Fiber to Fiber splicing (SM-SM, SM-MM, MM-MM, PM, etc.) and splicing loss measurement. 5. Setting up of Mach-Zender interferometer 6. Design of driver circuit for LED and Laser diode 7. Characterization of Erbium Doped Fiber Amplifier 8. Simulation of Basic FBG Fiber Loop Mirror Sensor Designing using OptiwavesoftwaveDesign of signal conditioning circuits for Photodetectors	

Semster III Course details

EE-624 – DIGITAL SYSTEM DESIGN USING FPGAs

Course Outcomes:

CO-1 :	Familiarized with the design of Combinational and Synchronous and Asynchronous Sequential Circuits. Gave an Overview of PLDs and PALs
CO-2 :	Covered basic introduction of VHDL and the basic language elements. Various Combinational and Sequential circuits were designed using VHDL
CO-3 :	In-depth analysis of Faults and testability in digital systems including modelling and detection
CO-4 :	Interfacing various sensors and reading/writing to/from various file formats. Implementing various modulation schemes
CO-5 :	Design of a RISC CPU, data and control path components. Introduction to various floating/fractional/fixed-point arithmetic operations. Implementing Data encryption/Decryption system, Error correction, communication modules, BERT

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Digital system design techniques:** CombinationalCircuitDesign-SynchronousSequentialCircuitDesign-MealyandMooremodel-Statemachine design-AnalysisofSynchronoussequentialcircuit-Stateequivalence-	12

	StateAssignmentandReduction-Analysis of Asynchronous Sequential Circuit - flow table reduction – races - state assignment - Design of Asynchronous SequentialCircuit-DesigningwithPLDs–OverviewofPLDs–ROMs-EPROMs–PLA–PAL-GateArrays–CPLDsandFPGAs,DesigningwithROMs-ProgrammableLogicArrays-ProgrammableArraylogic.	
Unit II:	**IIVHDL basics and computation module designs:** Introduction to VHDL - Behavioralmodeling - Data flow modeling - Structural modeling - Basic language elements –Entity–Architecture- Configurations–Arraysdeclaration-Subprograms&operator overloading-Packages& libraries – Advanced Features - Model simulation - Realization of combinational and sequential circuits using VHDL – Registers – Flip flops - counters – Shift registers – Multiplexers - sequential machine – Multiplier – Divider, ALU, MAC, CORDIC, Introduction toSynthesis.	6
Unit III	**Fault modeling, detection and test pattern generation algorithms:** Introduction to testing – Faults in Digital Circuits – Modeling of faults – Logical Fault Models – Fault detection – Fault Location – Fault dominance – Logic simulation – Test generation for combinational logic circuits –Testable combinationallogiccircuitdesign-IntroductiontoDesignforTestability-BIST.	6
Unit IV	**Digital system design with real-time I/O interface:** Sensorsinterface-uni-polar&bi-polarA/Dconverter-D/Aconverterinterface-displaydevicesinterface-RS232, USB,Ethernet,VGAinterface-RFdatalink-highvoltageswitchcontrol-realy/AC/DCmotor&buzzercontrol- PWMsignalgeneration-PS/2key-board&matrixkeypadinterface–digitalcamerainterface,arbitrarydata/signal generation–sensordataacquisitionandwriting/readingto/from.xlsxand.docfile-implementationofmodulation schemes	12
Unit V	**Contemporary designs and solutions:** Design of data path components, Control path components - Design of a simple RISC CPU - Debugging using Embedded Logic Analyzers - Audio codec (AC97) interface – Test-bench design - ChipScope Pro Analyzer - introduction to floating/fractional/fixed-point arithmetic operations - Xilinx Sys-Gen tools - MATLAB/VHDL interfacewithSys-Gentools-BERTinterface–implementationofDPCM,dataencryption/decryptionsystem,EC techniques, communication modules design, DA basedcomputations.	10

LIST OF EXPERIMENTS:

SL No	NAME OF EXPERIMENTS
01.	The Basic FPGA Design Flow 1. To understand use of XilinxISE 2. TounderstandXilinxSynthesisTechnologyorXST. 3. Familiarization of Xilinx Vivado DesignTools.
02.	Familiarization of FPGA Boards 1. Xilinx FPGA Boards (Virtex6,Kintex7) 2.Implementation ofFull adder, ALU , Memory and FIFO on FPGA
03.	Fault Detection Logic Implementation on FPGA 1. Stuck at Fault

	2.Memory BIST
04.	Implementation of RISC CPU on FPGA and debugging using Embedded Logic Analyzers.

REFERENCE TEXT BOOKS:

1. JesseH.Jenkins,"DesigningwithFPGAsandCPLDs",PrenticeHall,NJ,1994
2. FundamentalsofLogicDesign–CharlesH.Roth,5thed.,Cengage Learning.
3. Kevin Skahill, "VHDL for Programmable Logic", Addison -Wesley,1996
4. Z.Navabi,"VHDLAnalysisandModelingofDigitalSystems",McGRAW-Hill,1998
5. Digital Circuits and Logic Design – Samuel C. Lee ,PHI
6. Smith, "Application Specific Integrated Circuits", Addison-Wesley,1997
7. P.K.Lala,"DigitalCircuitTestingandTestability", AcademicPress,2002

AP-623 – Introduction to Fiber Optics

Course Outcomes:

CO-1	Understand the basics concepts of Fiber Optic Communication
CO-2	Understand all the sub-components of Fiber Optics
CO-3	Examine the working mechanism of Fiber Optics
CO-4	Illustrate the practical implementation of Fiber Optic Communication
CO-5	Summarize different applications of Fiber Optic Communication

Syllabus:

Units Divisions	Syllabus Details	Hours
Unit I:	**Optical Fibers:** Light Propagation in Optical Fibers, Optical fiber Modes and Configurations, Mode Theory for Circular waveguides, SM and GI Fibers, Fiber Materials, PhC fibers, Fiber fabrication. **Optical Fibers Characteristics:** Fiber Attenuation, Absorption losses, scattering losses, Radiation losses, Bending losses, Measurement of losses, Dispersion in fibers, Effect of dispersion in the communication link, Dispersion reduction, and compensation techniques.	**9**
Unit II:	**Power Launching and Coupling:** Source to Fiber launching and Launching Schemes for Coupling Improvements. Fiber to Fiber joints, Laser coupling to SM fiber, Fiber splicing, Optical Fiber Connector. **Optical Receivers:** Basic Concepts, Common Photodetectors, Receiver Design, Receiver Noise, Coherent Detection, Receiver Sensitivity, Sensitivity Degradation, Receiver bandwidth, and Performance	**9**
Unit III	**Fiber Amplifier:** Optical Amplification in rare-earth-doped fibers, Types of Fiber Amplifiers, EDFA, Amplifier Noise, Optical SNR, System Application, Raman Amplifiers, Wideband Optical Amplifier	**9**
Unit IV	**Optical Fiber Sensors:** Introduction, Classification and Types of Optical Fiber Sensors, Sensor Modulation techniques, Fiber Bragg Grating Sensors: Principle and Applications.	**9**
Unit V	**Overview of Optical Fiber Communication:** Lightwave communications, Optical Spectrum Bands, and Visible Units, Network Information rate and WDM concepts. Key Elements of fiber optics system, Standards for Optical fiber communications.	**9**

References Textbooks:

1. A.K. Ghatak & K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press 1998
2. G. Kaiser, Optical Fiber Communication, 4th Edition, Tata McGraw Hill 2008
3. J.C. Palais, Fiber Optic Communications, 4th Ed., Prentice-Hall Inc 1998
4. J.P. Dakin & B Culshaw, Optical Fiber Sensors, Vol. 1&2., Artech House 1998
5. K.T.V. Grattan & B.T. Meggitt, Optical Fiber Sensor Technology, Vol. 2, 1988

AP-512 – Advanced Photonics Laboratory

Course Outcomes:

CO-1 :	Characterization of Fiber Optics Devices
CO-2 :	Analyse the optical multiplexing techniques and its device performance
CO-3 :	Examine the working principle of different electro-optic and magneto-optic effects
CO-4 :	Illustrate the different beam characterization methods
CO-5 :	Understand the design of different spectroscopic systems

Syllabus:

Syllabus Details	Hrs
1. Characterization of Fiber Bragg grating 2. Power budget analysis using Optical Time Domain Reflectometer (OTDR) 3. Study of Time Division Multiplexing of digital signals 4. Study of a Wavelength Division Multiplexing(WDM) in optical fiber link 5. Study of Add/drop multiplexer 6. Study of Bit error rate and Eye pattern analysis 7. Setting up a Free space Laser Communication experiment link 8. Measurement of third order nonlinear optical coefficient using Z-scan 9. Study of Faraday effect 10. Design of a fiber optic sensor 11. Line coding and decoding, voice coding 12. Measurement of insertion loss of an isolator, coupler and multiplexer 13. Beat length measurement in birefringent fibers. 14. Laser Raman Spectroscopy Experiments 15. Holography **Note: Any 12 experiments are mandatory**	120 hrs

Semster IV Course details

AP-642 – Terahertz Devices and Applications

Course Outcomes:

CO-1	Interpret the concepts of terahertz technology
CO-2	Analyze the working principle of different types of terahertz signal sources
CO-3	Examine the working mechanism of different types of terahertz detectors
CO-4	Illustrate the practical implementation of fabrication of components and circuits for terahertz systems
CO-5	Summarize different applications of terahertz technologyfor imaging, sensing and communications

Syllabus:

Units	Syllabus Details	Hours
Unit I:	**Basics of Terahertz Technology:** Electromagnetic radiation and propagation fundamentals, Introduction to terahertz technology, Background, Terahertz gap, Key technological issues for terahertz technology, Advantages and limitations of terahertz waves, Material properties at mm and sub-mm frequencies	**9**
Unit II	**Terahertz Sources:** Terahertz sources based on electronics: Diodes,	**9**

	transistors, resonant tunnelling diodes, vacuum electronics; Terahertz sources based on photonics: Non-linear crystals, quantum cascade lasers, plasma-based source; Terahertz sources based on optoelectronics: Photomixer, photoconductive antenna and its types; Noises at terahertz frequencies in different sources	
Unit III	**Terahertz Detectors:** Terahertz detectors based on electronics: HOT electron bolometer, Heterodyne SIS receivers: Theory and Design, Superconducting tuning circuitries, HEB heterodyne receivers: Theory and Design, Terahertz MMICs: Theory and Design, Terahertz detectors based on photonics	**9**
Unit IV	**Terahertz Components:** Terahertz components: Metamaterials and plastic fibers, HEMT cryogenic amplifiers: Theory and Design, Antennas, Filters, Waveguides, Beam Splitter, Beam Combiner, Polarizer, Mirrors, Isolator, Circulator, Cameras, Fabrication Technologies, Metamaterial THz devices, Spintronic THz components.	**9**
Unit V	**Terahertz Applications:** Terahertz applications: Time domain Colinear and Non-colinear terahertz spectroscopy, Optical-pump-THz-probe Spectroscopy, Terahertz Imaging, Terahertz sensing and analysis, Terahertz wireless communication, Terahertz remote-sensing, 3D terahertz tomography system, Industrial applications, Space Communication, Cutting-edge terahertz technologies	**9**

References Textbooks:

1. A. Rostami, H. Rasooli, H. Baghban, Terahertz Technology: Fundamentals and Applications, Germany, Springer, 2011.
2. R. E. Miles, P. Harrison, D. Lippens, Terahertz Sources and Systems ", Dordrecht: Kluwer, Springer, 2000.
3. K. Sakai, Terahertz Optoelectronics, Springer, 2004.
4. H.-J. Song, T. Nagatsuma, Handbook of Terahertz Technologies, Devices and applications, Pan Stanford Publishing Pte. Ltd., 2015.
5. D. Saeedkia, Handbook of Terahertz Technology for Imaging, Sensing and Communications, Woodhead Publishing, 2013.

AP-643 – Free Space Optical Communications

Course Outcomes:

CO-1	Interpret the concepts of Free Space Optical Communication
CO-2	Understand all the sub-components
CO-3	Examine the working mechanism of FSOC
CO-4	Illustrate the practical implementation of FSOC
CO-5	Summarize different applications of FSOC such as VLC/UWOC

Syllabus:

Units Divisions	Syllabus Details	Hours
Unit I:	**Introduction FSOC/OWC,** Basic Link configuration of FSOC, various application areas of FSOC, Indoor Channel modelling, various link configurations, Artificial light interference effects in	**9**

	indoor channel.	
Unit II:	**Channel Modelling -Outdoor channel,** Atmospheric channel loss related issues, Atmospheric turbulence effects, Measurement of C_n^2, Various atmospheric turbulence models, Effects of atmospheric turbulence on laser beam propagation, Realization of atmospheric effects on OWC test beds	**9**
Unit III	**Modulation Techniques:** Importance of modulation in FSO, various modulation formats, selection criteria for modulation, basic modulation schemes OOK,PPM, PIM, DH-PIM, BPSK etc. and error propagation **FSO link Performance under atmospheric turbulence:** performance of FSO link in various modulation formats, comparison across the modulation formats, the turbulence-induced penalty in FSO link, Link budget analysis, Power budget analysis	**9**
Unit IV	**Mitigation techniques:** introduction, aperture averaging, various diversity techniques, spatial diversity, time diversity coding techniques, adaptive optics and other techniques.	**9**
Unit V	**Laser beam Tracking, pointing & acquisition:** Acquisition and Tracking systems, System description, Acquisition methodology, tracking and pointing control system, RF cross-link system design, link equation Intoduction to Free Space Quantum Optical Communication	**9**

References Textbooks:

1. Arun K. Majumdar, Free-Space Laser Communications Principles and Advances. Springer Publications
2. Hemani Kaushal, Free Space Optical Communication. Springer Publication
3. J. Franz and V.K. Jai, Optical Communication Systems. Narosa Publications
4. Morris Katzman, Laser Satellite Communications. Prentice Hall Inc 1991
5. Infrared Technology: Applications to Electro-Optics, Photonic Devices and Sensors, A.K. Jha

AP-631 – Laser Applications

Course Outcomes:

CO-1	Familiarize to a variety of applications on lasers
CO-2	Interpret how laser-based metrological techniques work
CO-3	Understand laser spectroscopy applications
CO-4	Investigate various methods of how a laser can be used for defence applications
CO-5	Summarize different applications of lasers

Syllabus:

Units	Syllabus Details	Hours
Unit I:	**Laser Metrology: Laser** for measurement of distance, length, velocity, acceleration; rotation sensing; RLG and FOG.	**6**
Unit II	**Laser Spectroscopy:** IR absorption Spectroscopy, Laser Raman spectroscopy, Laser induced breakdown spectroscopy (LIBS), laser-induced fluorescence (LIF), Tunable diode laser spectroscopy (TDLS), Terahertz spectroscopy, Photoacoustic spectroscopy, Instrumentation in	**12**

	laser spectroscopy, Isotope Separation & Enrichment. Bio-Medical Application of Lasers	
Unit III	**Holography:** Holographic interferometry and applications; Holography for non – destructive testing – Holographic components	**6**
Unit IV	**Industrial Application of Laser:** Laser cutting, Laser welding, Laser drilling, Laser marking, Photolithography, Laser-based unmanned ground vehicles	**9**
Unit V	**Defence Applications:** Low power laser applications including Laser Range finders-LRF (DPSSL, Eye Safe & High PRF) & Laser Target Designators; Dazzlers, Laser Warning receivers, Infrared counter measures, Laser Guidance; Laser-based navigation; Laser-based imaging; Laser-based remote sensing: Laser radar, laser radar seekers, LIDAR basic concept and applications	**12**

AP-508 – Computational Photonics

Course Objectives:

CO-1 :	Understand the simulation methos of photonics devices and fiber Optics
CO-2 :	Study on mode solution method of photonics devices
CO-3 :	Study on beam propagation method for Photonics devices
CO-4 :	Study on FDTD method for photonics band gap
CO-5 :	Understanding the recent advance in photonics Devices

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Mode Solver Method:** Theory of fully vectorial mode solvers in 2D and 3D structures, low-index polymer waveguides, high-index silicon (SOI) and GaAs/AlGaAs waveguides, buried, etched (rib, ridge), and diffused geometries commonly used in opto-electronics slot waveguides, slanted-wall and graded structures, plasmonic and microwave waveguides,	9
Unit II:	**Beam Propagation Method:** Theory and working of beam propagation method, Tutorials on MMI couplers, optical gratings, co-directional couplers or polarization converters.	9
Unit III	**FDTD Method:** Theory and working of FDTD method, Tutorials on photonics band gap simulation: 2D and 3D of different crystal lattices.	9
Unit IV	**Fiber Optics Modeling:** Simulation and modeling of single mode and multimode optical fiber using mode solver, FBG and Chirped FBG synthesis, photonic crystal fiber simulation	8
Unit V	**Nanodesign:** Mask designing for nanofabrication of different device geometry	7
Unit VI	**Introduction to Finite Element Method**	3

Reference Books:

1. S. Sujecki, Photonics Modelling and Design, CRC Press, 2015.
2. K. Okamoto, Fundamentals of Optical Waveguides, Academic Press, 2000.
3. A. Taflove, Computational Electrodynamics: The Finite-Difference Time Domain Method. Norwood, MA: Artech House, 1995.

AP-603 – Technology and Packaging of MEMS systems

Course Outcomes:

CO-1 :	Students to be able to understand concepts involved in MEMS
CO-2 :	Students to understand the technologies involved in MEMS fabrication and packaging, their advantages and limitations
CO-3 :	Students to be able to understand working principles in micro sensors and actuators
CO-4 :	Students to become capable of conceptualizing the design of a microsystem

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Evolution of Microsystems:** Concept & History of Micro systems & MEMS, Benefits of Micro Systems, Comparison between Microsystems & microelectronics, Multidisciplinary nature of microsystems development.	**2**
Unit II:	**Scaling Laws in Miniaturization:** Introduction to scaling, geometric scaling, scaling in rigid body dynamics, scaling in electrostatic forces, scaling in electromagnetic Electricity, scaling in fluid mechanics, Scaling in Heat Transfer.	**4**
Unit III	**Engineering, Science & Materials for Microsystems**: Atomic structure, Crystal Structures, Bonding in materials, Ionization, Doping in Semiconductors, Diffusion Process, Plasma Physics, Electrochemistry, Silicon as a substrate material for MEMS, Compounds of silicon, Si Piezo resistors, other Piezo electric materials, GaAs, Polymer, Materials used in packaging	**8**
Unit IV	**Fabrication of Microsystems**: Photolithography, Ion Implantation, Diffusion, Oxidation, chemical & physical vapor deposition, Epitaxial growth of films, Chemical etching, Plasma etching.	**8**
Unit V	**Micromachining processes:** Bulk Micromachining**,** Surface Micromachining, The LIGA Process.	**4**
Unit VI	**Working principles of microsystems:** Microsensors: Acoustics wave sensors, Biomedical & Bio sensors, Chemical Sensors, Optical Sensors, Pressure Sensors, Thermal Sensors. MEMS with Microactuators: Microgripper, Micromotors, Micro valves, Micro pumps, Micro accelerometer Microfluidics	**8**
Unit VII	**Microsystem packaging:** Levels in microsystem packaging, Interfaces in Microsystem packaging, Essential packaging technologies, 3-d Packaging, assembly of Microsystems. Multi User MEMS Program (MUMPs)	**4**

Lab Assignments		**Hrs**
Lab 1	To study the etching process in silicon	4
Lab 2	Thin film deposition and analysis	4
Lab 3	3D Printing	4

References Textbooks:

1] Tai-Ran Hsu, 'MEMS & Microsystem, Design and Manufacture',McGraw Hill, 2012
2] Physics of Semiconductor Devices by S.M. Sze,Wiley Publications(2006)
3] Mark J Jackson, Micro and Nano-manufacturing , Springer; First Edition, (2006)ISBN
4] Zheng Cui,Micro-nanofabrication: Technologies and Applications, Springer First Edition (2006),ISBN-10:3540289224
5] R. Kassing, P. Petkov,W.Kulish, C. Popov., Functional Properties of Nanostructured Materials. Springer (ISBN: 978-1-4020-4595-0 (Print) 978-1-4020-4594-3(Online)

References Textbooks:

1. A. K. Ghatak & K. Thyagarajan, Optical Electronics, Cambridge University Press,1989. References
2. A. Yariv, P. Yeh, Photonics: Optical Electronics in Modern Communications, The Oxford Series in Electrical and Computer Engineering, 2006.
3. B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007)
4. S. Sugano, N. Kojima (Eds.), Magneto-Optics, Springer Series in Solid-State Sciences, Vol. 128, 2000.
5. O. Svelto, Principles of Lasers, Plenum Press, New York, 1998.
6. P. W. Milonni and J. H. Eberly, Lasers, Willey Inter Science, 1988.

AP-624 – Semiconductor Photonic devices

Course Outcomes:

CO-1	Understand the basics of Semiconductor Physics
CO-2	Interpret all the optical properties and processes in semiconductors
CO-3	Examine the working mechanism of different kinds of LEDs and LASERs
CO-4	Illustrate the implementation of Modulation and Switching Devices
CO-5	Explain different types of photodiodes and photodetectors

Syllabus:

Units Divisions	**Syllabus Details**	**Hours**
Unit I:	**Review of Semiconductor Physics:** Energy Bands, Density of States, Fermi-level, PN Junction, Homo and Hetero Junction, Quantum Wells. Semiconductor Optoelectronic materials, Electron-hole pairs	**9**
Unit II:	**Light Emitting Diodes:** The electroluminescence Process, LED materials, Device configuration and Efficiency, LED structures, LED performance characteristics, Frequency response and Modulation bandwidth. LEDs for display and Lighting.	**9**
Unit III	**Semiconductor Lasers:**Junction Laser Operating Principles, Threshold Current, Heterojunction Laser, Distributed Feedback Lasers and Distributed Bragg Reflector, Ring Lasers: Single and Double, Master Oscillator Power Amplifier. VCSELS and Laser Diode Arrays. Advanced Semiconductor Laser: Quantum Well and Quantum Cascade Laser, Laser Modulation Bandwidth.	**9**
Unit IV	**Modulation and Switching Devices:** Analog and Digital Modulation of light sources, Franz-Keldysh and Stark-effect based Modulators, QW Electro-absorption modulator.	**9**
Unit V	**Photodetectors:** Types of photodetectors, Photoconductors, Junction photodiode, PIN photodiode and APD, Quantum Well IR Detectors, High Speed Measurements, Detectors for long wavelength operation, Wavelength selective detection, Coherent detection. CCDs and PICs.	**9**

References Textbooks:

1. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1995).
2. G. Ghione, Semiconductor Devices for High-Speed Optoelectronics, Cambridge University Press (2009)

3. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communication, Oxford University Press (2007), 6^{th} Ed., Ch.15-17.
4. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2^{nd} Ed. (2007), Ch.16, 17, and 18.
5. S. M. Sze, Physics of Semiconductor Devices, John Wiley & Sons, 3^{rd} Ed. (2021).
6. Streetman, Ben, and Sanjay Banerjee. Solid state electronic devices. Pearson Higher Ed, 2015.

AP-513 – Introduction to programming

Course Outcomes:

CO-1 :	Learn a language, Python, for expressing computations
CO-2 :	Develop an informal understanding of computational complexity
CO-3 :	Examine the process of moving from an ambiguous problem statement to a computational formulation of a method for solving the problem
CO-4 :	Illustrate the useful set of algorithmic and problem reduction techniques
CO-5 :	Use computational tools (including simple statistical, visualization, and machine learning tools) to model and understand data

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Introduction to Python & Simple Numerical Programs Installing Python and Python IDEs, Basic elements of Python, Variables and assignment, branching programs, strings and input, loops, Simple codes, approximate solutions, Floats, Newton–Raphson	60 hrs Practicals
Unit II:	Functions, scoping, and abstraction Functions, Scoping, Using functions to modularize code, Functions as objects,	
Unit III	Structured types and mutability Ranges and iterables,Strings, Tuples, Ranges, and Lists, SETS, Dictionaries	
Unit IV	Recursion, global variables, modules and files, classes Fibonacci Numbers, Palindromes, Global Variables, modules, files, testing and debugging, Abstract data types and classes, some important complexity classes	
Unit V	Object-oriented programming, algorithms, data structures, Plotting Search algorithms, sorting algorithms, Matplotlib	

References Textbooks:

1. Introduction to Computation and Programming Using Python, by John V Guttag, MIT Press

AP 514 – Introduction to Biophotonics

Course overview: This course is a multidisciplinary course offered as an elective for M.Sc. and M.Sc. (Tech) photonics in the 3^{rd} semester only.

Course Prerequisite: Any basic course on optics

Course Outcomes:

CO-1	Understand the importance of multidisciplinary concepts and biophtonics
CO-2	Understand the Basics of biological matter
CO-3	Apply the knowledge gained in optics for biomaterials research
CO-4	Learn various spectroscopy techniques
CO-5	Analyse and interpret the outcomes of bioimaging and spectroscopy

Syllabus:

Unit	Syllabus details	Hours
Unit 1	**Introduction to Biophotonics:** Overview, light-biological matter interaction, applications	**5**
Unit 2	**Basics of Biology:** Introductory Concepts, Cellular Structure, Various Types of Cells, Chemical Building Blocks, Interactions Determining Three-Dimensional Structures of Biopolymers, Other Important Cellular Components, Cellular Processes, Protein Classification and Function, Organization of Cells into Tissues, Types of Tissues and Their Functions, Tumors and Cancers	**10**
Unit 3	**Bioimaging:** Principles and Techniques: Simple Microscope, Compound Phase Contrast Microscopy, Dark-Field Microscopy, Differential Interference Contrast Microscopy (DIC) Fluorescence Microscopy, Confocal Microscopy, Multiphoton Microscopy, Optical Coherence Tomography, Total Internal Reflection Fluorescence Microscopy, Near-Field Optical Microscopy	**10**
Unit 4	**Fundamentals of Light-Matter Interactions:** Interactions Between Light and a Molecule, Nature of Interactions, Interaction of Light with a Bulk Matter, Fate of Excited State, Various Types of Spectroscopies, Electronic Absorption Spectroscopy, Electronic Luminescence Spectroscopy, Vibrational Spectroscopy, Spectroscopy Utilizing Optical Activity of Chiral Media, Fluorescence Correlation Spectroscopy (FCS)	**10**
Unit 5	**Nanotechnology for Biophotonics:**Bionanophotonics, The Interface of Bioscience, Nanotechnology, and Photonics, Semiconductor Quantum Dots for Bioimaging Metallic Nanoparticles and Nanorods for Biosensing	**10**

References:

[1] Y. Yeh, V. V Krishnan, Introduction to Biophotonics, 2018. https://doi.org/10.1142/9789813235694_0001.

AP-608 – Machine Learning techniques for Sensor Data Analytics

Course Outcomes:

CO-1 :	Interpret the concepts machine learning
CO-2 :	Analyze different types of machine learning techniques
CO-3 :	Examine situations where supervised learning can be used
CO-4 :	Illustrate implementation of supervised and unsupervised learning.
CO-5 :	Summarize different applications of machine learning techniques in sensors

Syllabus:

Units	Syllabus Details	Hrs

Unit I:	Introduction: Role of Machine learning techniques in sensor data analytics, Learning from data, Machine learning examples, Simple model for Machine Learning, Types of learning,	6
Unit II:	Theory of generalization: Feasibility of learning, Hoeffding inequality, complexity of hypothesis set, growth function, VC dimension, Training versus testing	7
Unit III	Supervised Learning: Perceptron, Linear classification, Linear regression, Logistic regression, Neural Network, Backpropagation algorithm, Support Vector Machines, Radial Basis Functions, K-nearest neighbour, Decision Trees, Bayesian Learning, Deep learning, Feature extraction and dimensionality reduction: Curse of dimensionality, Principal Component analysis, Linear discriminant analysis	12
Unit IV	Unsupervised Learning: Clustering, K-means clustering, hierarchial clustering	10
Unit V	Machine Learning issues: Overfitting, Validation, Occam's razor, Agglomerative Sampling bias, Data Snooping	10

References Textbooks:

1. Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", Springer Vieweg,2012.
2. S. Haykin, "Neural Networks, A Comprehensive Foundation", Pearson Education Inc.,2004.
3. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition,2001.
4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer,2006.
5. Y. S. Abu-Mostafa, M. Magdon-Ismail, and Hsuan-Tien Lin, Learning from data,AMLbook.com
6. Y. S. Abu-Mostafa, Learning from data, Caltech lectures(online)
7. S. Sarkar, Introduction to Machine Learning, NPTEL course, IIT Kharagpur(online).

QT 622: Nonlinear and Quantum Optics

Course Outcomes:

CO-1 :	Understand basic of Nonlinear optics
CO-2 :	Understand the mode polarization
CO-3 :	Application of non-liear optics
CO-4 :	To understand phase modulation , ultrashort pulses
CO-5 :	To know the quantum optics

Nonlinear optics: Simple Harmonic Oscillator model, Anharmonic oscillator model, Nonlinear polarization, Nonlinear wave equation, Nonlinear susceptibilities and mixing coefficients. Second harmonic generation, Phase matching condition, Various phase matching techniques, Periodically poled materials and their applications in non-linear optical devices, Sum and difference frequency generation, Optical parametric amplification (OPA) and oscillation (OPO), Third harmonic generation, four wave mixing and Self phase-modulation Optical Kerr effect, Self-focusing, Optical bistability, Stimulated Raman Scattering and Stimulated Brilluoin Scattering, Introduction to ultrashort pulses, Ultrashort pulse generation through mode-locking, Supercontinuum generation.

Quantum Optics: Field quantization, Correlation functions, photon statistics, shot noise of the photodetectors, Poissonian and sub-Poissonain light, Photon bunching and antibunching, HBT experiment, single photon sources, Coherent states and squeezed states, Phasor diagram, generation and detection of squeezed light, Quantum noise, Phase space representation and Wigner function.

Text/References

1. R. W. Boyd, Nonlinear Optics, Academic Press, 2008
2. Peter E. Powers, Fundamentals of Nonlinear Optics, CRC Press, 2011.
3. Mark Fox, Quantum Optics: An Introduction, Oxford master series in physics, 2007
4. A guide to experiments in Quantum Optics, Hans-A Bachor, T. C. Ralph, 3rd edition, Wiley, 2019