MSc Photonics Revised Scheme (2023 Admission)

Semester	Number of courses offered by the department						
	Major 4 credits	**Minor** 4 credits	**MDC** 4 credits	**AEC** 2/3 credits	**SEC** 3 credits	**VAC** 2 credits	**Total credits**
I	1	1	1	1 (3 cr)	1	2	22
II	1	1	1	1 (3 cr)	1	2	22
III	2+1 (lab 3cr)	1	1	1 (2 cr)			21
IV	4	1			1		23
V	4 +1 (lab 3cr)	1					23
VI	4+1 (lab 3cr)	1					23
		Internship**					2
Total credits/courses	73	24	12	8	9	8	136
**Not counted as a course Exit with BSc in Photonics (Total credits = 136)							
VII	4	1					20

VIII	1 Courses + seminar/open ended labs/online (2 credits) + Project (12 credits) Or 3 Major Courses + Mini project (4 credits) + seminar/open ended labs/online course (2 credits)	1					22
Total credits/courses	Hon. (Research): 107 Hon. : 107	32	12	8	9	8	178
Exit with BSc (Honours with Research) in Photonics (Total credits = 178) Exit with BSc (Honours) in Photonics (Total credits = 178)							
IX	5 Courses + online (2 credit**)						20-24
X	Major project + online (2 credit**)						20-24
Total credits	151	32	12	8	9	8	222
** Instead of taking two online courses worth 2 credits each, a student can opt for one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will be 24, and in the other semester, they will be 20. Exit with MSc (Five-Year Integrated) in Photonics (Total credits = 222)							

MDC: Multi-Disciplinary Courses
AEC: Ability Enhancement Courses
SEC: Skill enhancement Courses
VAC: Value Added Courses

Semester III

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-0301	Python Programming	Core	4	3-0-2	50	50	100
23-351-0302	Electricity and Magnetism	Core	4	4-0-0	50	50	100
23-351-0303	Classical Mechanics	Core	4	4-0-0	50	50	100
23-351-0304	Mathematics III	MDC	4	3-1-0	50	50	100
23-351-0305	Instrumentation Workshop	AEC	2	1-1-0	50		50
23-351-0306	Lab	Core	3	0-0-6	100		100
Semester Credits	21 (Cumulative credits: 65)						

Semester IV

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-0401	Thermal and Statistical Physics	Core	4	4-0-0	50	50	100
23-351-0402	Mathematical physics	Core	4	4-0-0	50	50	100
23-351-0403	Electronics	Core	4	4-0-0	50	50	100
23-351-0404	Quantum mechanics I	Core	4	4-0-0	50	50	100
23-351-0405	MOOC*	Elective	4	4-0-0		100	100
23-351-0406	General Photonics Lab	SEC	3	0-0-6	100		100
Semester Credits	23 (Cumulative credits: 88)						

* 23-351-0405 MOOC (1 course of 4 credits/2courses of 2 credits)

Semester V

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-0501	Quantum Mechanics II	Core	4	4-0-0	50	50	100
23-351-0502	Electrodynamics	Core	4	4-0-0	50	50	100
23-351-0503	Spectroscopy	Core	4	4-0-0	50	50	100
23-351-0504	Biophotonics	Core	4	4-0-0	50	50	100
23-351-0505	Elective I: MOOC*	Elective	4	4-0-0	0	100	100
23-351-0506	General Physics Lab	Core	3	0-0-6	100		100
Semester Credits	23 (Cumulative credits: 111)						

* 23-351-0505 MOOC (1 course of 4 credits/2courses of 2 credits)

Semester VI

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-0601	Laser Physics	Core	4	4-0-0	50	50	100
23-351-0602	Fiber Optics	Core	4	4-0-0	50	50	100
23-351-0603	Computational Methods in Optics and Photonics	Core	4	4-0-0	50	50	100
23-351-0604	Optical Instrumentation	Core	4	3-0-2	50	50	100
23-351-060X	Elective II	Elective	4	3-0-2	50	50	100
23-351-0605	Computational Lab	Core	3	0-0-6	100		100
Semester Credits	23 (Cumulative credits: 134)						

List of Electives II

23-351-0606 Optical Sensor Technology

23-351-0607 Photonic Crystals and Optical Metamaterials

23-351-0608 Fourier Optics & Optical Signal Processing

Internship

Students have to complete an internship of 2 credits (60 Hours of work) before the beginning of Semester VII. **Cumulative Credits: 136**

Exit with 3-year UG Degree OR continue to the 4th year.

Semester VII

Course Code	Course Name	Type	Credits	Hours/ week L-T-P-S	Marks distribution		
					CA	ESE	Total
23-351-0701	Optoelectronics	Core	4	3-0-2	50	50	100
23-351-0702	Condensed Matter Physics	Core	4	4-0-0	50	50	100
23-351-0703	Non-linear optics	Core	4	4-0-0	50	50	100
23-351-0704	Photonics Lab 1 and Seminar	Core	4	0-0-6-1	100 +50		100+ 50
23-351-070X	Elective III	Elective	4	4-0-0	50	50	100
Semester Credits	20 (Cumulative credits: 156)						

S: Seminar

List of Electives III

23-351-0706 Nanophotonics

23-351-0707 Laser spectroscopy

23-351-0708 Quantum Optics & Quantum Computing

23-351-0709 Advanced Electromagnetic Theory

Semester VIII

For Honours with Research

Course Code	Course Name	Type	Credits	Hours/ week L-T-P-S	Marks distribution		
					CA	ESE	Total
23-351-0801	Elective IV: MOOC II	Elective	4			100	100
23-351-0802	Elective V: MOOC III	Elective	4			100	100
23-351-0803	Project	Core	12	0-0-24	300		300
23-351-0804	Seminar	Core	2	0-0-0-2	100		100
Semester Credits	22 (Cumulative credits: 178)						

For Honours

Course Code	Course Name	Type	Credits	Hours/ week L-T-P-S	Marks distribution		
					CA	ESE	Total
23-351-0805	Mini Project	Core	4	0-0-8	100		100
23-351-0806	Photonics lab 1	Core	4	0-0-8	100		100
23-351-0801	Elective IV: MOOC II	Elective	4	4-0-0		100	100
23-351-0802	Elective V: MOOC III	Elective	4	4-0-0		100	100
23-351-0804	Seminar	Core	2	0-0-0-2	100		100
23-351-080X	Elective VI	Elective	4	3-0-2	50	50	100
Semester Credits	22 (Cumulative credits: 178)						

List of Electives IV & V

MOOC courses on

Optical Communication or Solar Cells

If no MOOC courses are available, these two courses will be offered by the department in online mode.

List of Electives VI

23-351-0807 Optomechanical Engineering

23-351-0808 Laser Systems and Laser Applications

Exit with 4-year UG Degree OR continue to the 5th year.

Semester IX

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-0901	Industrial Photonics	Core	4	4-0-0	50	50	100
23-351-0902	Photonics lab 2	Core	4	0-0-8	100		100
23-351-0903	Elective VII: MOOC IV**	Elective	2			100	100
23-351-090X	Elective VIII	Elective	4	4-0-0	50	50	100
23-351-090X	Elective IX	Elective	4	4-0-0	50	50	100
23-351-090X	Elective X	Elective	4	4-0-0	50	50	100
Semester Credits for Photonics Major	22 (Cumulative credits: 200)						

List of Electives VIII-X

23-351-0904 Quantum Communications

23-351-0905 Ultrafast Photonics

23-351-0906 Plasma Physics

23-351-0907 Microscopic Techniques

Semester X

Course Code	Course Name	Type	Credits	Hours/ week L-T-P	Marks distribution		
					CA	ESE	Total
23-351-1001	Major Project	Core	20	0-0-40	600		600
23-351-1002	Elective XI: MOOC V**	Elective	2			100	100
Semester Credits for Photonics Major	22 (Major pathway: 22) Cumulative credits: 222						

**Instead of taking the online course worth 2 credits, a student has the option to select one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will total 24. Consequently, they won't need to enroll in the MOOC course in the other semester, and the maximum credits for that semester will be 20.

Detailed Syllabus

23-351-0301 Python Programming

CO	**CO Statement**	**CL**	**Class Hrs**	**Lab Hrs**
CO1	Demonstrate proficiency in Python programming fundamentals, including syntax, control structures	Understand	8	0
CO2	Analyze different data structures and develop basic software solutions	Analyze	7	0
CO3	Apply Object-Oriented Programming principles to design and implement modular software solutions	Apply	7	0
CO4	Understand code reusability and maintainability.	Understand	6	0
CO5	Develop skills in GUI programming using open-source tools to create interactive graphical applications with user-friendly interfaces.	Apply	6	0
CO6	Understand web development concepts and networking fundamentals, enabling them to build basic web applications and network applications using open-source tools and socket programming.	Understand	7	0
CO7	Apply data processing and analysis techniques using Python libraries such as NumPy, Pandas	Apply	6	0
CO8	Apply Matplotlib and Seaborn to manipulate and visualize data effectively.	Apply	7	0
CO9	Understand building machine learning pipeline for well-known models.	Understand	6	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1		2		
CO2	3	1	1		2		
CO3	3	1	1		2		
CO4	3	1	1		2		
CO5	3	1	1		2		
CO6	3	1	1		2		
CO7	3	1	1		2		
CO8	3	1	1		2		
CO9	3	1	1		2		

3-High; 2-Medium; 1-Low

Module I: Foundations of Python Programming

Introduction to Python and its Applications - Setting up Python Environment and Basic Syntax Control Structures, Functions, and Recursion - Data Structures: Lists, Tuples, Dictionaries, Sets-

Intermediate Python Features: File Handling, Exception Handling

Module II: Object-Oriented Programming (OOP) with Python

Principles of OOP and Class Creation - Inheritance, Polymorphism, and Encapsulation- Advanced OOP Concepts: Class Methods, Static Methods, Properties - Design Patterns in Python - GUI

Programming with open source tools.

Module III: Web Development and Networking

Introduction to Web Development with Flask - Creating Basic Web Applications – Database Management with Python and SQL - Networking and Socket Programming - Building Network Applications

Module IV: Data Processing and Analysis

Introduction to NumPy and Pandas- Data Manipulation and Analysis with Pandas – Data Visualization with Matplotlib and Seaborn - Introduction to Machine Learning with scikit-learn - Building Basic Machine Learning Models

References:

1. Eric Matthes, Python Crash Course, 2nd Edition, No Starch Press, 2019
2. Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, 2013
3. Dusty Phillips, Python 3 Object-Oriented Programming, 3rd Edition, Packt Publishing, 2018
4. Zetcode, Python GUI Programming with Tkinter, ZetCode, 2021
5. Miguel Grinberg, Flask Web Development, O'Reilly Media, 2018
6. Joel Grus, Data Science from Scratch: First Principles with Python, 2nd Edition, O'Reilly Media, 2019
7. Wes McKinney, Python for Data Analysis, 2nd Edition, O'Reilly Media, 2017
8. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016
9. Luciano Ramalho, Fluent Python, 2nd Edition, O'Reilly Media, 2021
10. Brian Okken, Python Testing with pytest, Pragmatic Bookshelf, 2017

23-351-0302 Electricity and Magnetism

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Discuss the fundamental laws governing static electric fields and its implementation for topractical uses.	Understand	9	0
CO2	Explain the elementary concepts of magnetism, effect of magnetic field on moving charges, laws related to current induced magnetic fields and properties of various magnetic materials.	Understand	10	0
CO3	Explain the fundamentals of alternating currents.(Understand)	Understand	10	0
CO4	Employ the basic circuit laws and DC network theorems in the analysis of electrical circuits.	Apply	6	0
CO5	Identify the behaviour of combination of circuit elements across single phase ACsupply.	Analyze	9	0
CO6	Examine the phenomenon of series and parallel resonance in single phase AC circuits.	Analyze	10	0
CO7	Describe operating principle of practical electrical devices.	Understand	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	2	1				
CO2	3	2	1				
CO3	3	2	1				
CO4	3	2	1				
CO5	3	2	1				
CO6	3	2	1				
CO7	3	2	1				

3-High; 2-Medium; 1-Low

Module I

Quantization and conservation of charge, Millikan's oil drop experiment. Concept of electric flux- Gauss's law- Gauss's law in cylindrical, planar and spherical symmetry-applications. – Electric potential: equipotential surfaces, potential due to point charge, group of point charges and due to electric dipole. Capacitance: capacitors in series and parallel connections, storing energy in an electric field, Spherical capacitor, cylindrical capacitor, capacitor with dielectric. Electric current, current density, Ohm’s law and its limitations, resistance and resistivity, comparison between EMF and potential difference.

Module II

Magnetic field (B), Magnetization vector (M); Magnetic Intensity (H);Magnetic Susceptibility and permeability; Relation between B, H, M, Hall Effect, Biot-Savart's Law and its simple applications: straight wire and circular loop; Current Loop as a Magnetic Dipole and its Dipole Moment, torque on a current loop, Ampere's Circuital Law and its application to Solenoid and Toroid, Electromagnetic induction: Faraday's Law of induction, Lenz's law, induced electric field, inductance, self and mutual induction, energy stored in a magnetic field, introduction to dia, para and ferro-magnetic materials, motion of charged particle in magnetic field, Lorentz force. Cyclotron and synchrotron.

Module III

Alternating currents- peak, rms and average values. AC through inductance, capacitance, resistance and their combinations. LC oscillations, damped oscillations, concept of phase difference between voltage and current, phasor diagram, concept of impedance, AC power, power factor. Kirchhoff's laws, source transformations, voltage and current division rule, practical and ideal voltage /current sources, Maxwell's mesh or loop method, Network theorems (for DC): Thevenin's, Norton's, super position and maximum power transfer theorems.

Module IV

Analysis of LC and RC circuits, series and parallel LCR circuits. Resonance, Acceptor and Rejecter circuits, Q-factor, relation of Q-factor to band width. Transformer- theory and construction. EMF equation, circuit parameters and equivalent circuit, distinction between ideal and practical transformer, Losses in transformer. Choke coil, Fuses, circuit breakers, relays, AC and DC generators.

References:

1. Fundamentals of Electricity and Magnetism -9th edition, D. N. Vasudeva, S. Chand and company (2002) (Text)
2. Network theory and filter design - Aatre, New Age International Publication 2nd edition (2003) (Text)
3. Brijlal & Subramaniam, Electricity and Magnetism-6 Th edition, Ratna Prakashan Mandir, Educational & University Publication, Barya ganj, New Delhi(2006).
4. Basic Electrical Engineering - volume 18 Th edition,Thereja, S. Chand limited (2005).
5. K. K. Tewari, Electricity & Magnetism with electronics -7 th edition, S.Chand& Co. Pvt. Ltd., Ram Nagar, New Delhi(2007).
6. Electricity and Magnetism- R. Murugesan, S. Chand and Company, 4th Edition (2001)
7. Electricity and Magnetism Berkeley Physics Course Vol.2, EdwardPurcell, 2 nd Revised Edition, NewYork, Mc Graw Hill Science 2017

23-351-0303 Classical Mechanics

After completing this course, the students will be able to:

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe various types of constraints acting on a system.	Understand	9	0
CO2	Describe conservation theorem and symmetry properties.	Understand	8	0
CO3	Apply Lagrange's theorem for simple situations.	Apply	10	0
CO4	Solve the central force problem.	Apply	10	0
CO5	Apply theory of small oscillations to study the normal modes of molecules like CO_2.	Apply	10	0
CO6	Review the equations of motion in Poisson bracket form.	Understand	7	0
CO7	Discuss Hamilton-Jacobi equations.	Understand	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	2	1				
CO2	3	2	1				
CO3	3	2	1				
CO4	3	2	1				
CO5	3	2	1				
CO6	3	2	1				
CO7	3	2	1				

3-High; 2-Medium; 1-Low

Module I

Constraints: types of constraints, difficulties associated with constraints, generalized coordinates Kinetic energy of a system in terms of generalized velocities. Calculus of Variation: Hamilton's Principle, techniques of the calculus of variations, Lagrange's equation from Hamilton's principle. Generalized momenta, cyclic coordinates. Conservation theorems and symmetry properties: Conservation of linear momentum, Conservation of angular momentum, Conservation of energy, Noether's theorem (no proof).

Module II

Applications of Lagrangian formulation: motion of a particle in space, Atwood's machine, bead sliding on rotating wire, simple pendulum, harmonic oscillator.

Central force problem: reduction to equivalent one body problem, equations of motion and first integrals, classification of orbits and stability condition for orbits. Kepler's laws.

Hamiltonian mechanics: Hamiltonian of a system, Hamilton's equations of motions, Canonical transformations, Generating functions.

Module III

Theory of small oscillations: equilibrium and potential energy, Normal modes, Normal modes of CO2 type molecules. Rigid body dynamics-Euler's angles - equations of motion, symmetric top, Corioli's force.

Module IV

Poisson Brackets: fundamental properties of PB, Equations of motion in Poisson Bracket form, PB and integrals of motion, Canonical invariance of PB, Lagrange brackets. Hamilton-Jacobi equation for Hamilton's principal function, Action angle variables in system of one degree of freedom.

References

1. Classical Mechanics, H Goldstein, C Poole and J Safko, 3rd edition, Addison Wesley (2005) (Text)
2. Classical Mechanics – G Aruldhas, PHI learning, (2014) (Text)
3. Classical Mechanics- Rana and Joag, Tata McGrawHill (1992)
4. Classical Mechanics - V B Bhatia, Narosa Pub.(1997)
5. Classical Mechanics of particles and rigid bodies Kiran C Gupta, Wiley Eastern Ltd.(1998)
6. Mechanics L. D Landau and E. N Lifshitz., Butterworth Heinemann,3rd Ed (2002)
7. Classical Mechanics C R Mondal, Prentice Hall India, (2002)

23-351-0304 Mathematics III

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand curvilinear coordinate system	Understand	8	0
CO2	Apply curvilinear coordinate to physical systems with spherical and cylindrical symmetry	Apply	8	0
CO3	Understand the concept of vector space and the properties of vectors in linear vector space	Understand	8	0
CO4	Apply concepts of vector space in physical systems	Apply	8	0
CO5	Understand algebraic and transcendental equations, interpolation and simultaneous equations	Understand	6	0
CO6	Apply numerical methods to solve algebraic and transcendental equations, simultaneous equations and perform differentiation and integration	Apply	8	0
CO7	Understand initial value problems and boundary value problems	Understand	8	0
CO8	Apply numerical methods to solve initial value and boundary value problems	Apply	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	1	
CO2	3	2	1	1	2	1	1	
CO3	3	2	1	1	2	1	1	
CO4	3	2	1	1	2	1	1	
CO5	3	2	1	1	2	1	1	
CO6	3	2	1	1	2	1	1	
CO7	3	2	1	1	2	1	1	
CO8	3	2	1	1	2	1	1	

3-High; 2-Medium; 1-Low

Module I

Curvilinear coordinates: description of curvilinear coordinate system, Line integral, Area element and area vector, Volume element and volume integral, Expression for the above in rectangular, Spherical and cylindrical coordinate systems, Conversion of unit vectors in spherical and cylindrical coordinates into rectangular coordinates and vice versa.

Expression for gradient, divergence, curl and Laplacian operator in rectangular and curvilinear coordinate systems.

Module II

Vector space: field, definition of vector space, Inner product, Norm, Schwart'z inequality, Dual vectors and dual space, Bra and Ket notations, Linearly independent and dependent vectors, Orthonormal vectors, Schmidt's othogonalisation, Basis, Dimension, Change of basis, Linear operator, Adjoint and Hermitian operators, Matrix representation of operators, Similarity and unitary transformations, Eigenvalue and eigenvectors, Projection operator, Function space, Hilbert space.

Module III

Solution of algebraic and transcendental equations: iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations using matrix inversion method, Interpolations: Newton's and Lagrange's formulas.

Numerical differentiation: First and second order derivatives, Forward, backward and central difference methods.

Numerical integration: Trapezoidal rule, Simpson's rule, Gaussian quadrature method, Least-square curve fitting, Straight line and polynomial fits.

Module IV

Numerical solution of ordinary differential equations, Initial value problems, Euler's method and Runge-Kutta methods.

Numerical solutions of partial differential equations, Boundary value problems, Finite difference method, Solution to Laplace and Poisson equations using finite difference method.

References

1. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
2. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
3. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
4. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
5. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
6. Differential Equations - 3rd Ed., Shepley L. Ross, Wiley. 2007 (Text).
7. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978 (Text).
8. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).
9. Introductory Methods of Numerical Analysis- S S Sastry Prentice Hall India (2001) (Text)

23-351-0401 Thermal and Statistical Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe thermodynamic systems and processes, employ laws of thermodynamics in relevant thermodynamic processes and predict the efficiency of heat engines based on Carnot's cycle.	Understand	8	0
CO2	Discuss entropy, thermodynamic functions, and TdS relations.	Understand	7	0
CO3	Apply Maxwell's thermodynamical relations ,Gibbs Helmholtz equations and classify phase transitions and critical phenomena.	Apply	9	0
CO4	Relate thermal and electrical conductivity to Transport processes.	Analyze	6	0
CO5	Discuss the concept of phase space as well as microstates and macrostates and explain the statistical origin of thermodynamics and its connection to entropy.	Understand	6	0
CO6	Describe the concept of microcanonical, canonical, and grand canonical ensembles, compute various thermodynamic properties of ideal gas.	Apply	9	0
CO7	Discuss Maxwell Boltzmann statistics and velocity distribution, and the theory of Brownian motion.	Understand	6	0
CO8	Differentiate Fermi-Dirac and Bose-Einstein distribution and discuss the thermodynamics of blackbody radiation and Bose-Einstein condensation.	Understand	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3						
CO2	3	3						
CO3	3	3						
CO4	3	3						
CO5	3	3						
CO6	3	3						
CO7	3	3						
CO8	3	3						

3-High; 2-Medium; 1-Low

Module I

Thermodynamic systems, thermodynamic equilibrium, thermodynamic variables, equation of states, laws of thermodynamics, thermodynamic process and cycles, application of first law to heat capacities, reversible and irreversible processes, conditions for reversibility, heat engine, Carnot's cycle and Carnot's engine, Carnot's theorem, Clausius theorem and inequality.

Entropy - change in entropy in reversible and irreversible processes, entropy and disorder, entropy of ideal gas. temperature- entropy diagram, entropy and second law of thermodynamics, Nernst Heat Theorem.

Module II

Thermodynamic functions- Enthalpy, Helmhlotz function, Gibbs function, Maxwell's thermodynamic relations, TdS relations-application of Maxwell's thermodynamical relations, Clausius-Clapeyron equation, thermodynamic potential, Gibbs Helmholtz equations.

Phase transitions and critical phenomena - phase diagram, first order phase transition, Clausius-Clapeyoron equation in the context of first order phase transition, Kirchhoff's equation, second order phase transition. Ehrenfest's equations, liquid helium and superfluidity.

Transport processes – momentum transport and viscosity, energy transport and thermal conductivity, charge transport & electrical conductivity.

Module III

Macroscopic and microscopic systems- general descriptions, quantum states and phase space, density distribution in phase space, Liouville's theorem, statistical origin of thermodynamics, entropy from the statistical mechanics point, ensemble, microcanonical, canonical and grand canonical ensembles.

Module IV

Distribution laws - classical and quantum statistics, Maxwell-Boltzmann distribution, velocity distribution, equipartition of energy, relationship between entropy and probability, partition function of monoatomic gas, Brownian motion.

Quantum Statistics- Bose-Einstein and Fermi-Dirac distributions, Bosons and Fermions, thermodynamic behavior of ideal Bose gas, thermodynamics of black body radiation, specific heats of solids, B-E condensation, F-D statistics. thermodynamic behavior of an ideal Fermi gas, electron gas in metals.

References

1. Thermal Physics-Kittel and Kroemer, W. H. Freeman; Second edition (1980) (Text).
2. Heat and Thermodynamics -D S Mathur, Sultan Chand and Sons, Revised Fifth edition (2004) (Text).
3. Heat and Thermodynamics – Zeemansky and R. H. Dittman, Tata McGraw Hill (1997)
4. Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanics- S.C. Garg, R.M. Bansal, C.K. Ghosh, TataMcGraw Hill Education Private Limited; 2nd edition (2017).
5. Heat and thermodynamics- Brijlal and Subramanium, S Chand (2008)
6. Statistical Mechanics - K Huang, John Wiley & sons, 2nd edition (2008) (Text)
7. Modern Thermodynamics-D. Kondepudi. Ilya Prigogene, John Wiley sons (1998)
8. Statistical Mechanics- Kamal Singh, S. Chand and Co, New Delhi, 1st edition (1988)
2. Statistical Mechanics- R. K. Pathria, Butternorth-Heinemann, (1972)
3. Modern Physics- Beiser, Tata Mc Graw Hill, (2002)
4. Statistical Physics- Berkeley Physics Course Vol 5, F Reif, Tata McGraw Hill, 2011
5. Statistical Mechanics-R. K. Pathria, 2nd edition, Elsevier (2002)

23-351-0402 Mathematical Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand complex variables, analytical functions and power series	Understand	6	
CO2	Understand Cauchy integral formula and perform integrations	Understand	8	
CO3	Understand tensors and fundamental operations, covariant and contravariant tensors.	Understand	8	
CO4	Understand Christoffel symbols, curvature tensor and analysis of Cartesian tensors.	Understand	8	
CO5	Understand Fourier series and Fourier transform and Laplace transform.	Understand	6	
CO6	Utilizing Laplace transform methods to solve initial value problems, boundary value problems, and differential equations.	Apply	8	
CO7	Understand special functions.	Understand	8	
CO8	Apply special functions in solving differential equations.	Apply	8	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	1	
CO2	3	2	1	1	2	1	1	
CO3	3	2	1	1	2	1	1	
CO4	3	2	1	1	2	1	1	
CO5	3	2	1	1	2	1	1	
CO6	3	2	1	1	2	1	1	
CO7	3	2	1	1	2	1	1	
CO8	3	2	1	1	2	1	1	

3-High; 2-Medium; 1-Low

Module I

Functions of complex variables: Analytic functions, Power series, Taylor and Laurent series, Contour integration, Cauchy's theorem, Cauchy's integral formula. Integration involving branch cuts and branch points.

Module II

Tensor analysis: definition, Law of transformations, Rank of tensor, Covariant and contravariant tensors. Algebra of tensors, Lowering and raising of indices, Contraction of tensors, Fundamental tensors, Metrics, Covariant derivatives, Christoffel symbols, Curvature tensor, Cartesian tensors.

Module III

Fourier series: definition, Applications and properties. Fourier Transform: properties, Convolution theorem, Solving differential equations using FT. Laplace Transform: definition, Laplace Transform of simple functions, Solving differential equations using Laplace Transform. Initial value problems, Boundary value problems, Solving differential equations using transform methods.

Module IV

Sturm-Liouville problem, Hermitian differential equations, Beta and gamma function. Series solutions to differential equations, Partial differential Equations, Separation of variable method, Laplace Equation in spherical polar coordinates and spherical harmonics. Orthogonal functions, Legendre, Bessel, and Hermite and Laguerre differential equations and their solutions.

References

1. Tensor Calculus, David C. Kay, McGraw Hill; Revised Edition, 2011 (Text)
2. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
3. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
4. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
5. Vector Analysis with an Introduction to Tensor Analysis - Murray R Spiegel, Tata McGraw Hill (1975) Schaum Series (Text).
6. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
7. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
8. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978 (Text).
9. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).

23-351-0403 Electronics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the various configurations of transistors and familiarize with the working.	Understand	6	4
CO2	Understand the working of transistors as amplifiers and analyze the working and types of oscillators.	Analyze	6	4
CO3	Understand the working and frequency response of operational amplifiers.	Understand	6	4
CO4	Familiarize with the various operational amplifier circuits and its applications.	Apply	5	4
CO5	Apply Boolean algebra in logic circuit design.	Apply	6	4
CO6	Explain the working of combinational logic circuits and flip flops.	Analyze	5	4
CO7	Identify the different types of modulation techniques – Amplitude, Frequency and Phase Modulation.	Analyze	6	4
CO8	Define information theory, entropy, mutual information and describe the various error detection and correction techniques.	Analyze	5	2
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3		1				
CO2	3	3		1				
CO3	3	3		1				
CO4	3	3		1				
CO5	3	2		1				
CO6	3	3		1				
CO7	3	2		1				
CO8	3	2		1				

3-High; 2-Medium; 1-Low

Module I

Bipolar Junction Transistors, PNP and NPN structures, Principle of operation, Relation between current gains in CE, CB and CC, Input and output characteristics of common emitter configuration, load line, Transistor as a switch, transistor as an amplifier, single stage and multistage amplifiers, circuit diagram and working of Common Emitter (RC coupled) amplifier with its frequency response, Concept of transistor biasing, Oscillator: crystal, optoelectronic, RC phase shift, Hartley, Colpitts, Wien Bridge.

Module II

Ideal Amplifier, Operational Amplifiers, frequency response of Op-Amps, fundamental circuits, voltage follower, inverting and non-inverting op-amps, summing and differential amplifiers, op-amp integrator, differentiator and its applications, op-amp peak detector, Applications of op-amps: filters, comparators, sample and hold circuit, waveform generators.

Module III

Digital fundamentals: Boolean algebra, Boolean theorems, Synthesis of Boolean functions, Karnaugh diagram, logic gates, fundamental logic operations, Universal gate (NAND & NOR) combinational logic circuits, half adder, full adder, half subtractor, full subtractor, multiplexer, demultiplexer, encoder, decoder, flip-flops, RS latches, level clocking, D latcher, D flip flops, JK flip flop, JK Master slave flip-flops. Registers and counters, shift register, controlled shift registers, ripple counters, decoding gates, synchronous counters, ring counters, changing the counter modulus, decade counters.

Module IV

Digital Communication: Amplitude Modulation, double and single sideband techniques, Frequency Modulation and demodulation techniques, bandwidth requirements, pulse communication, pulse width, pulse position, pulse code modulation, information theory, entropy, mutual information, error detection and correction techniques.

References

1. Basic Electronics, Mitchel Schultz and Grob, 12th edition, McGraw-hill Education, 2015.
2. Basic Electronics and Linear Circuits, N.N. Bhargava, Tata McGraw-hill Publishing Company Limited, 2008.
3. Principles of Electronics, V. K. Mehta & Rohit Mehta, 11th edition, S. Chand Publication, 2014.
4. Digital circuits and design, S. Salivahanan and S. Arivazhavan, Vikas Pub. 4th Edn, 2012.
5. Fundamentals of digital circuits, A. Anadan, PHI, 2006.
6. Communication Systems, A B Carlson, 5th edition, McGraw Hill, 2011.
7. Principles of Communication Systems, Herbert Taub, Donald Schilling & Gautam Saha, 4th edition, McGraw Hill, 2017.
8. Digital Communication, Nishanth Nazimudeen, 1st edition, Cengage, 2018.

23-351-0404 Quantum Mechanics I

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the shortcomings of classical mechanics and the emergence of quantum theory	Understand	6	0
CO2	Illustrate the concept and significance of wave packets	Understand	9	0
CO3	Explain the properties and interpretations of wave functions	Understand	7	0
CO4	Apply time-independent and time-dependent Schrödinger equations	Apply	8	0
CO5	Discuss the fundamental postulates of quantum mechanics	Understand	8	0
CO6	Apply linear operators and eigenfunctions in quantum mechanics	Apply	7	0
CO7	Solve quantum mechanical problems, including particle in a box and potential barriers	Apply	10	0
CO8	Apply the Schrödinger equation to systems with spherically symmetric potentials	Apply	5	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	1	1	2				
CO2	3	1	1	2				
CO3	3	1	1	2				
CO4	3	3	1	1	2	3		
CO5	3	1	1	1	1	1		
CO6	3	1	1	1	2	2		
CO7	3	3	1	1	2	2		
CO8	3	3	1	1	2	1		

3-High; 2-Medium; 1-Low

Module I

Origin of quantum theory: Blackbody radiation, ultraviolet catastrophe, Planck's formulation of black body radiation, photoelectric effect, Einstein's quantum theory of photoelectric effect, Compton effect.

Wavelike properties of particles: matter waves, de Broglie hypothesis, Davisson and Germer experiment, the wave-particle duality.

Wave packets: localized wave packets, the uncertainty principle, consequences of the uncertainty principle, uncertainty relations, the motion of wave packets, propagation of wave packets without distortion, group and phase velocities.

Module II

Schrödinger wave function, Born's interpretation of wave functions, Schrödinger's equation for a particle subjected to forces, wave function and its interpretations, probability, probability current density and continuity equation, expectation values, Ehrenfest's theorem, admissibility conditions of wave functions, normalizations of wave functions, box normalization, time-dependent and time-independent Schrödinger equations, stationary states and superposition principle.

Module III

Postulates of Wave Mechanics, dynamical variables as operators, linear operators, commutator brackets, eigen functions and eigenvalues, Hermitian operators and their properties, orthogonality conditions, Schimidt's orthogonalization procedure, physical significance of eigenfunctions and eigenvalues, degeneracy, simultaneous measurability of observables, general uncertainty relations.

Representation in continuous bases: position and momentum representations in quantum mechanics, connecting position and momentum representations, matrix and wave mechanics.

Module IV

Applications of Schrödinger equation: particle in a box, square well potential with rigid walls, square well potential with finite walls, square potential barrier and quantum tunnelling, alpha decay, linear harmonic oscillator, particle in a spherically symmetric potential, separation of R, Θ and Φ equations, Hamiltonian of two interacting particles, rigid rotator, hydrogen atom, energy eigenvalues, hydrogen wave function, radial probability density functions and hydrogen atom orbitals.

References

1. Quantum Physics-Eisberg and Resnik, John Wiley Sons(2002) (Text)
2. Concepts of Modern Physics-Beiser, Tata McGraw Hill (2002) (Text)
3. Quantum Mechanics- G Aruldhas, Prentice Hall India (2004) (Text)
4. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley & Sons, (2001)
5. Principles of Quantum Mechanics -R. Shankar, Springer, (2014)
6. Quantum mechanics- Mathews and Venketesan, Tata McGraw Hill (2006)
7. Quantum Mechanics-Thankappan V K, New Age International, 2nd edition (2003)
8. Introduction to Quantum Mechanics – David J Griffiths, Pearson, 3rd Edn, (2018)
9. Mastering Quantum Mechanics- Essentials, Theory and Applications, Barton Zwiebach, The MIT Press, Cambridge, Massachusetts (2022)

23-351-0501 Quantum Mechanics II

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Differentiate between the Schrödinger picture, Heisenberg picture, and interaction picture in quantum mechanics	Understand	5	0
CO2	Apply the operator method for solving the harmonic oscillator problem	Apply	10	0
CO3	Predict eigenfunctions and eigenvalues of angular momentum operators	Apply	8	0
CO4	Understand Pauli Spin matrices and spin angular momentum	Understand	7	0
CO5	Apply time-independent and time-dependent approximation methods in quantum mechanics	Apply	10	0
CO6	Inspect transition rates in absorption/emission processes	Analyze	5	0
CO7	Understand Scattering theory and scattering cross sections	Understand	6	0
CO8	Apply scattering theory to study scattering from various potentials	Apply	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	1			
CO2	3	2	1	1	3			
CO3	3	3	1	2	2			
CO4	3	3	1	2	2	1		
CO5	3	2	1	2	3	1		
CO6	3	3	1	3	3	1		
CO7	3	3	1	3	2	2		
CO8	3	3	1	3	2	2		

3-High; 2-Medium; 1-Low

Module I

Parity operator, Solution of linear harmonic oscillator: Operator method, coherent states, matrix representation of creation, annihilation, number, position, and momentum operators of the harmonic oscillator. Pictures of quantum mechanics, Schrödinger picture, Heisenberg picture and interaction picture.

Module II

Orbital angular momentum, General formalism of angular momentum, eigenfunctions and eigenvalues of Jz and J2, matrix representation of angular momentum, geometrical representation of angular momentum, eigenfunctions and eigenvalues of Lz and L2. Spin angular momentum: general theory of spin, Pauli spin matrices.

Module III

Time independent perturbation-first order and second order correction, the stark effect, Degenerate perturbation theory; Variational method, hydrogen atom; WKB approximation, tunnelling through a potential barrier.

Time dependent perturbation theory: first order approximation, transition probability for constant and harmonic perturbations, Fermi's Golden rule.

Module IV

Scattering theory: scattering amplitude and differential cross section of spinless particles, partial wave analysis, Optical theorem, partial wave analysis for inelastic scattering, Born approximation, scattering by hard sphere.

References

1. Quantum Mechanics: Concepts and Applications, 2nd Edition, Nouredine Zettili, John Wiley & Sons, 2009 (Text)
2. Principles of Quantum Mechanics -R. Shankar, Springer, (2014) (Text)
3. Quantum Mechanics G Aruldhas, Prentice Hall India, (2004)
4. Quantum mechanics Mathews and Venketesan, Tata McGraw Hill (2006)
5. Modern Quantum Mechanics- J J Sakurai, Pearson Education, Revised Ed (2003)
6. Quantum Mechanics-Thankappan VK, New Age International (P)Ltd, 2nd edition (2003)
7. Mastering Quantum Mechanics- Essentials, Theory and Applications, Barton Zwiebach, The MIT Press, Cambridge, Massachusetts (2022)

23-351-0502 Electrodynamics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the concepts of electrostatics, electric field, electric potential and energy density	Understand	7	0
CO2	Apply the concepts of electrostatics to solve the problems relating to electric Field and electric potential	Apply	8	0
CO3	Apply the concepts of magnetostatics to solve the problems relating to magnetic field and Magnetic potential	Apply	8	0
CO4	Solve problems related to electromagnetic boundary conditions	Apply	7	0
CO5	Understand the concepts related to Faraday's law and Maxwell's equations	Understand	8	0
CO6	Analyse the propagation, reflection and transmission of plane waves	Analyse	10	0
CO7	Explain magnetism as a relativistic phenomenon of electricity	Understand	7	0
CO8	Explain the significance of gauge transformations in physics, particularly in the Lorentz and Coulomb gauges	Understand	5	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1	1			
CO2	3	1	1	1			
CO3	3	1	1	1			
CO4	3	3	1	1			
CO5	3	1	1	1			
CO6	3	1	1	1			
CO7	3	3	1	1			
CO8	3	3	1	1			

3-High; 2-Medium; 1-Low

Module I

Electrostatics: Electric field, Gauss's Law in integral and differential forms, applications of Guass's law, Scalar potential, Energy of continuous charge distribution, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, Dielectrics, induced dipoles, polarization and field of a polarized object, Guass's law for dielectric media, Displacement field, linear dielectric and dielectric constant, energy and forces in dielectric systems.

Module II

Magnetostatics: Magnetic fields & magnetic forces, Biot-Savart law, Ampere's law, Applications of Amperes law, Magnetic vector potential, Magnetization, Torque and forces on magnetic dipoles, The field of a magnetized object, Ampere's law in magnetized material, Boundary conditions, Magnetic susceptibility and permeability.

Module III

Faraday's law of electromagnetic induction, energy and magnetic field, Maxwell's equation in vacuum and dielectric media, Solutions of Maxwell's equation in vacuum and dielectric media, Poynting's theorem, conservation of energy and momentum, Reflection and refraction of EMW at dielectric boundaries, Snell's law, total internal reflection, Brewster's angle. Electromagnetic waves in conductors, reflection at a conducting surface, frequency dependence of permittivity.

Module IV

Vector and Scalar potentials, gauge transformations- Lorentz and Coulomb gauges. Relativistic Mechanics- proper time, proper velocity, Compton scattering, Magnetism as relativistic phenomenon. Transformation of fields, the field tensor, four vectors, Maxwell's equation in tensor form.

References

1. Introduction to Electrodynamics, David J Griffiths, Cambridge University Press 4th edition (2020) (Text)
2. Classical Electrodynamics J.D Jackson, Wiley, 3rd Edition (2007) (Text)
3. The Feynman Lectures on Physics, Richard P Feyman, Vol 1&2, Narosa Publishing house (2008)
4. Concepts of Modern Physics, Arthur Beiser and Shobhit Mahajan, Tata Mc GrawHill (2009)
5. Electricity and Magnetism K K Tewari, S Chand & Company, 3rd Edition (2007)
6. Electricity and Magnetism D.N Vasudeva, S Chand & Company (2002)
7. Classical Electrodynamics- P S Sengupta, New Age International, 2nd Edition (2015)
8. Electromagnetic Theory and wave propagation- S N Ghosh, Narosa Publishers 2nd Ed (2002)
9. Introduction to special theory of relativity, R Resnick, Wiley India edition (2010)

23-351-0503 Spectroscopy

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the formation of fine and hyper-fine structure of spectral lines and the relative intensities of spectral lines.	Understand	8	
CO2	Utilize coupling schemes like LS coupling and jj coupling to determine spectral terms and term symbols based on electronic configuration.	Apply	7	
CO3	Analyze the Zeeman effect, distinguish between normal and anomalous Zeeman effect, and evaluate Zeeman Shift.	Analyze	8	
CO4	Compare the classical and quantum interpretations of the Stark effect in Hydrogen.	Analyze	7	
CO5	Describe the formation of rotational and vibrational spectra of molecules.	understand	8	
CO6	Apply vibrational and IR spectroscopy for identifying simple molecular structure.	Apply	7	
CO 7	Utilize the Franck-Condon principle to interpret intensity of electronic transitions in diatomic molecules.	Apply	8	
CO 8	Determine the molecular structure using Raman and IR spectroscopy techniques.	Apply	7	
	Total number of hours		60	

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	1	1	1	
CO2	3	2	1	1	1	1	1	
CO3	3	3	1	1	1	1	1	
CO4	3	3	1	1	1	1	1	
CO5	3	2	1	1	1	1	1	
CO6	3	3	1	1	1	1	1	
CO7	3	3	1	1	1	1	1	
CO8	3	3	1	1	1	1	1	

3-High; 2-Medium; 1-Low

Module I

Vector atom model-quantum numbers
Symmetry of atomic states, equivalent and nonequivalent electrons, normal and inverted atoms. Spectra of one electron systems: Expression for spin orbit interaction, fine structure of Hydrogen Atom, ionized Helium, alkali atoms, fine structure of doublet states- Sodium D1, D2 lines, Lande interval rule, Lamb shift, Intensity of spectral lines. Hydrogen spectra- Hyperfine structure.
Two electron systems: Spectral terms and term symbols based on electronic configuration. LS coupling, jj coupling, Pauli's exclusion principle, Hund's rule of multiplicity, selection rules, intensity rules

Module II
Zeeman effect: Normal and anomalous Zeeman effect, classical interpretation of normal Zeeman Effect, explanation based on vector atom model, Lande's g factor, Evaluation of Zeeman Shift, Zeeman effect in Sodium atom, experimental arrangement. Intensity distribution of Zeeman lines: BDO rule, Keiss and Megger's rule. Paschen- Back effect: Splitting of Sodium lines, selection rules, Zeeman and Paschen –Back effect in Hydrogen.
Stark effect : Experiment, Stark effect in Hydrogen, weak field and strong field effect: First order and second order stark effect in Hydrogen.
X-ray spectrum, continuous and characteristic X-ray spectra

Module III
Rotational spectra of diatomic molecules as rigid rotor, intensity of rotational lines, The effect of isotopic substitution, energy levels and spectrum of non-rigid rotor.
The vibrating diatomic molecule - simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating rotator - CO_2 and H_2O molecule. Interaction of rotation and vibrations, the vibrations of polyatomic molecules and their symmetry, the influence of rotation on the spectra of linear molecules

Module IV
Electronic spectra of diatomic molecules - Born-Oppenheimer approximation, vibrational coarse structure - progressions. Intensity of vibrational transitions – the Franck-Condon principle. Dissociation energy and dissociation products. Rotational fine structure of electronic-vibrational transitions - the Fortrat diagram. Predissociation.
Raman effect - classical theory, elementary quantum theory, pure rotational Raman spectra - linear molecules, vibrational Raman spectra polarization of light and Raman effect, structure determination by IR and Raman spectroscopy-simple examples, fundamentals of SERS.

References

1. Introduction to Atomic Spectra, H. E. White, McGraw-Hill Inc., US (1934). (Text)
2. Elements of Spectroscopy – Gupta, Kumar and Sharma, Pragathi Prakashan Meerat, 6th edition (2011) (Text).
3. Fundamentals for Molecular Spectroscopy, 4th Ed., C. N. Banwell and E. M. McCash, McGraw Hill Education (2017) (Text).
4. Molecular structure and Spectroscopy (2nd Edition), G. Aruldhas, Prentice Hall of India (2007).

23-351-0504 Biophotonics

CO	CO Statement	CL	Class Hrs	Lab Hrs	PSO
CO1	Understand the basic theory and science of interaction of light with cells and tissues.	Understand	8	0	1,2
CO2	Understand different light delivery systems	Understand	7	0	1,2
CO3	Understand fundamentals of optical imaging	Understand	7	0	1,2
CO4	Analyze different optical imaging techniques	Analyze	8	0	1,2
CO5	Understand different optical biosensors	Understand	10	0	1,2
CO6	Understand photodynamic therapy	Understand	5	0	1,2
CO7	Understand optical tweezers and analyze its applications	Understand	7	0	1,2
CO8	Analyze different tissue engineering techniques using light	Analyze	8	0	1,2
	Total Number of Hours		60	0	

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eye and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomography, Fluorescence microscopy, resonance energy transfer imaging

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Fluorescence, confocal and multiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging

MODULE III

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, evanescent waves and interferometric

Flow Cytometry: basis, flurochromes for flow cytometry, DN Aanalysis. Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, two photon photodynamic therapy.

MODULE IV

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, semiconductor Quantum dots for bio imaging. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration

Refences

1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003)
2. Biomedical Photonics -A handbook - editor Tuan.Vo Dinh (CRC Press) (2002)

23-351-0601 Laser Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain line broadening mechanisms.	Understand	6	
CO2	Describe Planck's radiation law and processes of absorption and emission of radiation.	Understand	6	
CO3	Discuss the required conditions for laser action.	Understand	10	
CO4	Solve rate equations for two, three and four level systems.	Apply	10	
CO5	Describe various laser cavity modes and its propagation.	Understand	10	
CO6	Predict the stability of laser systems.	Apply	8	
CO7	Describe various pulse shortening techniques and its use.	Understand	6	
CO8	Analyse and apply the safety requirement of high power lasers.	Apply	4	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2			1	
CO2	3	3	1	2			1	
CO3	3	3	1	2			1	
CO4	3	3	1	2			1	
CO5	3	3	1	2			1	
CO6	3	3	1	2			1	
CO7	3	3	1	2			1	
CO8	3	3	1	2			1	

3-High; 2-Medium; 1-Low

Module I

Decay of excited states, emission broadening and linewidth due to radiative decay, broadening due to collisional decay, Doppler broadening, Voigt profile, quantum mechanical description of radiating atoms, cavity radiations-Planck's law, absorption and stimulated emission, Einstein's coefficients.

Module II

Absorption and gain, population inversion, saturation intensity, development and growth of a laser beam, threshold requirements, laser gain saturation, laser output fluctuations, laser amplifiers, regenerative amplifiers, rate equations - two, three and four level systems, pumping pathways.

Module III

Laser cavity modes - longitudinal and transverse, Fabry-Perot cavity modes, Gaussian shaped transverse modes, stable curved mirror cavities - ABCD matrices, cavity stability criteria, Gaussian beams, Hermite-Gaussian mode, propagation of Gaussian beams using ABCD matrix

Module IV

Unstable resonators, Q-switching, Gain switching, Mode locking, pulse shortening using GVD, pulse compression with gratings and prisms, ultrashort pulse laser and amplifier system, ring lasers.

Laser systems: He-Ne laser, Argon ion laser, CO_2 laser, Free-electron laser, Ruby laser, Nd:YAG laser, Titanium sapphire laser.

References

1. Laser Fundamentals, W T Silfvast, Second Edition, Cambridge University Press, New Delhi 2008 (Text)
2. Lasers - Fundamentals and Applications, K Thyagarajan and Ajoy Ghatak, Second Edition, Springer, New York, 2010 (Text)
3. Laser Physics, Peter W Milonni and Joseph H Eberly, Wiley, 2010
2. Principles of Lasers, Orazio Svelto, Fifth Edition, Springer, 2010
3. Lasers, Anthony E Siegman, Mill Valley, Calif.: University Science Books, 1986

23-351-0602 Fibre Optics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the theory of propagation of light in planar and cylindrical waveguides.	Understand	6	
CO2	Describe the formation of modes in a planar optical waveguide.	Understand	6	4
CO3	Classify optical fibers based on their refractive index profiles.	Understand	3	4
CO4	Examine the loss mechanisms in optical fibers and to compute various losses.	Analyze	6	4
CO5	Compare different types of pulse broadening mechanisms in optical fibers.	Understand	6	
CO6	Practice the use of various standard optical fiber connectors and couplers.	Apply	4	6
CO7	Analyze various techniques for the testing of optical fibre systems.	Analyze	6	4
CO8	Analyze the functioning of optical fiber sensors.	Analyze	8	8
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	1	1	2			1	
CO2	3	3	1	2			1	
CO3	3	1	1	2			1	
CO4	3	3	1	2			1	
CO5	3	1	1	2			1	
CO6	3	3	1	2			1	
CO7	3	1	1	2			1	
CO8	3	3	1	2			1	

3-High; 2-Medium; 1-Low

Module I

Optical waveguides, numerical aperture, modes in planar waveguides, Goos-Hanchen effect, evanescent field, cylindrical fibres, step index and graded index fibres, single mode and multimode fibres, cut of wavelengths, integrated optics, channel waveguides, electro optic waveguides, i/p and o/p couplers, e-o and m -o modulators, applications of integrated optics - lenses, grating, spectrum analysers.

Module II

Transmission characteristics of optical fibres, attenuation, absorption and scattering losses, wavelengths for communication, bend losses, dispersion effects in optical fibres: material, waveguide dispersions, modal birefringence and polarization maintaining fibres, nonlinear effects in optical fibres: nonlinear losses, self-phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.

Module III

Optical fibre measurements: attenuation, dispersion band width, refractive index profile. OTDR, testing of optical fibre systems, eye pattern techniques.

Fabrication and characterization of silica, polymer fibres and photonic crystal fibres, erbium doped fibres, fibre components, couplers, connectors, packaging, splicers, cables, fiber joints, fiber polishing, industrial, medical and technological applications of optical fibre.

Module IV

Fibre optic sensors: advantages of fibre optic sensors, intensity modulation and interference type sensors, intrinsic and extrinsic fibre sensors, wavelength modulated sensors, fibre Bragg grating and fibre long period grating sensors, distributed fibre optic sensors, polarisation modulation type sensors, Sagnac interferometer and fibre optic gyroscope, temperature, pressure, force and chemical sensors.

References

1. Optical Fibre Communication, J. M. Senior, Prentice Hall India, 1994 (Text)
2. An introduction to Fiber Optics, Ghatak and Thyagarajan, Cambridge University Press, 1998 (Text).
3. Optical Fibre Communication Systems, J. Gowar, Prentice Hall India, 1995
4. Fibre optic communication, J. Palais, Prentice Hall India, 1988.
5. Fundamentals of Fibre Optic Telecommunication, B. P. Pal., Wiley Eastern, 1994.
6. Integrated Optics, R. G. Hunsperger. Springer Verlag, 1998
7. Fundamentals of Fibre Optics, B. P. Pal, Wiley Eastern, 1994
8. Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc, 2006.
9. Fibre Optic Sensors - Principles and Applications, B. D. Gupta, New India Publishing, 2006.
10. Fibre Optic Communication Systems, 3rd Edition - G.P. Agrawal, John Wiley and Sons, 2002

23-351-0603 Computational Methods in Optics and Photonics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand fundamental concepts in Python to solve mathematical problems.	Understand	4	0
CO2	Understand the basics of Mathematica in solving algebraic and differential equations.	Understand	8	0
CO3	Apply the knowledge of eigenvalue problems to analyze the band structure of photonic crystals.	Analyze	8	0
CO4	Apply ABCD matrix method for modelling optical systems.	Apply	8	0
CO5	Understand the fundamentals of the FDTD method.	Understand	8	0
CO6	Apply FDTD method to simulate the optical response of simple optical systems.	Apply	8	0
CO7	Understand Finite Element Method.	Understand	8	0
CO8	Apply FEM to simulate the optical response of simple optical systems.	Apply	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	1	1	1	1	3	2	3	
CO2	1	1	1	1	3	2	3	
CO3	1	1	1	1	3	2	3	
CO4	1	1	1	1	3	2	3	
CO5	1	1	1	1	3	2	3	
CO6	1	1	1	1	3	2	3	
CO7	1	1	1	1	3	2	3	
CO8	1	1	1	1	3	2	3	

3-High; 2-Medium; 1-Low

Module I

Introduction to Mathematica: overview of Mathematica software and its capabilities. Basics of the Mathematica interface: notebook structure, cells, evaluation, and syntax. Solving algebraic equations, differential equations, and systems of equations in Mathematica. Using built-in functions such as Solve, NSolve, and DSolve.

Maxwell equations and the wave equation, introduction to time-harmonic Maxwell equations and the Helmholtz equation.

Module II
Solving eigenvalue problems in electromagnetism, propagation of light in photonic crystals and calculation of band structure. ABCD matrix and ray tracing: introduction to the ABCD matrix method for optical systems. Ray tracing using matrix methods and transfer matrix method.

Module III
Basic principles of FDTD: discretization of space and time, finite differences, and time-stepping. Spatial discretization: discretization of the electromagnetic field components (E and H fields) in space using finite differences. Temporal discretization and Yee grid, discretization of time using finite differences or central differences, staggered grid arrangement used in FDTD method. Placement of electric field components (E) at cell faces and magnetic field components (H) at cell edges.
Boundary Conditions in FDTD, implementing boundary conditions in FDTD simulations. Perfectly Matched Layer (PML) boundary conditions for absorbing boundaries.

Module IV
Finite Element Method and its relevance in optics and photonics. Basic concepts: discretization, variational formulation, and finite element modelling. Weak formulation of partial differential equations and its application in FEM. Implementing FEM for optical simulations.

References

1. Mathematica by Example, by Martha L. Abell and James P. Braselton, Academic Press Inc., 2007 (text)
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley (Text).
3. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
4. An introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text)
5. Computational Physics, Mark Newman, Amazon Digital Services, 2012 (Text).
6. Absorption and Scattering of Light by Small Particles, Craig Bohren and Donald Huffman, John Wiley and Sons, 1998 (Text).
7. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House 1995, (Text).
8. David B Davidson - Computational electromagnetics for RF and microwave engineering - Cambridge University Press, 2011 (Text).
9. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson, Springer-Verlag New York, 2013 (Text).
10. The Mathematical Theory of Finite Element Method, Susanne C. Brenner and L. Ridgway Scott, Springer-Verlag New York Inc., 2007 (Text).

23-351-0604 Optical Instrumentation

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Design optical magnifiers and achromatic doublets.	Apply	6	0
CO2	Understand the working of telescopes and adaptive optical techniques.	Understand	9	0
CO3	Illustrate the working of different types of spectrometers and the mounting techniques.	Understand	8	0
CO4	Compare the spectrometers based on their performance.	Apply	7	0
CO5	Understand different methods in optical metrology.	Understand	9	0
CO6	Design velocimeters and vibrometers based on laser doppler techniques.	Apply	6	0
CO7	Describe the working of basic analytical instruments.	Understand	8	0
CO8	Design spectrometers for various applications.	Apply	7	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1	1	
CO2	3	3	1	2	1	1	3	
CO3	3	3	1	2	1	1	1	
CO4	3	3	1	2	1	1	1	
CO5	3	3	1	2	1	1	3	
CO6	2	3	1	2	1	1	1	
CO7	3	3	1	2	1	1	1	
CO8	3	3	1	2	1	1	1	

3-High; 2-Medium; 1-Low

Module I

Lens systems: Principal and meridional rays, magnifiers, ophthalmic lenses, achromatic doublets and collimators, afocal systems, relay systems and periscopes, indirect ophthalmoscopes and fundus camera.

Telescopes: transmissive telescopes and resolution, reflecting telescopes, one-, two- and three-mirror telescopes, astronomical telescopes, adaptive optics, space telescopes, field-aperture telescope.

Module II

Spectrometers: prism spectrometers, deviation and dispersion, mounting arrangements, Littrow and Wadsworth mountings, grating spectrometers, resolution and resolving power, mounting

arrangements, Paschen-Runge, Czerny-Turner and Fastie-Ebert mountings, the Rowland mounting, Eagle mounting, Fourier transform spectrometers based on interferometers, Michelson and Twyman-Green interferometer-based Fourier transform spectrometers, Fabry-Perot spectrometer, Mach-Zehnder and spherical Fabry-Perot interferometers.
Spectrometer configurations: single pass and double pass spectrometers, double monochromator spectrometers.
Comparison between resolution, resolving power, throughput and signal to noise ratio of different spectrometers.

Module III
Optical Metrology: range finders, optical RADAR, curvature and focal length measurement, Moiré technique, Talbot effect, thickness measurement, interferometric methods in small distance measurements, velocity and vibration measurements, velocity measurements using stroboscopic lamps, laser speckle photography and particle image velocimetry, laser Doppler velocimetry, optical vibrometers, different types of laser doppler vibrometers.

Module IV
Analytical Instruments: UV-Vis-IR spectrophotometers, Beer-Lambert's law, microwave and IR spectrometers , spectrofluorometers, FTIR spectrometer, Raman spectrometer.

References

1. Geometrical and instrumental Optics, Volume 25, edited by Daniel Malacara, Academic Press, (1988 (Text).
2. Handbook of Optical Engineering, Edited by Daniel Malacara and Brian J Thompson, Marcel Dekker Inc, 2001 (Text).
3. Fundamentals of Molecular spectroscopy, C N Banwell, McGraw-Hill Book Company, 4th edition, 2017 (Text).
4. Handbook of Analytical instruments, second edition, R S Khandpur, McGraw-Hill Education Private Limited (2006) (Text).

23-351-0606 Optical Sensor Technology

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe the principles of measurement used in different sensing schemes.	Understand	8	
CO2	Compare the sensitivity of simple optical sensors.	Understand	6	6
CO3	Explain the application of important interferometric techniques in high precision measurements.	Understand	4	
CO4	Analyze the features and applications of a variety of optical fiber sensors used for the sensitive measurements of various physical and chemical parameters.	Analyze	8	8
CO5	Construct and study the response of some sensing systems and understand the basic elements required for the realization of sensors for a particular measurand.	Apply	8	8
CO6	Distinguish various optical fibre sensors based on modulation.	Analyze	6	4
CO7	Examine the role of optical micro-cavities for sensing applications.	Understand	2	4
CO8	Explain some emerging sensors based on photonic crystal fibers and fiber loop ringdown spectroscopy.	Understand	3	
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	1	1	2			1	
CO2	3	3	1	2			1	
CO3	3	1	1	2			1	
CO4	3	3	1	2			1	
CO5	3	3	1	2			1	
CO6	3	3	1	2			1	
CO7	3	3	1	2			1	
CO8	3	3	1	2			1	

3-High; 2-Medium; 1-Low

Module I

Introduction to sensors, Active and Passive sensors, Sensor performance parameters, light beam as a sensing tool (optical sensor) - broad classification of optical sensors, photoelectric effect, photoconductivity, photodiode, phototransistor. Simple optical sensors - single and double optic lever; Method of Triangulation; Projected fringe technique; Remote sensing using laser-lidar for atmospheric remote sensing, lidar equation.

Module II
Interferometry for precision measurements, two-beam interferometry- Michelson, Mach Zehnder, Sagnac interferometers and applications, fringe displacement and fringe counting; Homodyne interferometer, heterodyne interferometer, super heterodyne interferometry; Multiple beam interference,Fabry Perot etalon and applications, Electron speckle pattern interferometry; Photoelastic measurements; Moire technique.

Experiential Learning: Moire pattern- displacement and refractive index (liquid) measurement, radius of curvature, focal length of spherical lenses.

Module III
Light transmission in microbend optical fibres- microbend OFS- measurements with microbend sensors; Evanescent wave (EW) phenomenon – Absorption and fluorescence, Beer lambert law, absorption and complex index, evanescent wave FOS, chemical sensors using EWFOS, evanescent wave fluorescence based sensor; Surface Plasmon resonance based fiber sensor-principle and applications; Fibre Bragg grating and Long period grating sensor, Distributed fiber optic sensing and applications- OTDR and its applications, fully distributed & quasi-distributed systems; FO smart sensing-basic architecture and example

Experiential Learning:
Study the shift in absorption or fluorescence characteristics of dyes/nanoparticles with pH and concentration. Evanescent wave optical fiber sensor- U shaped, Tapered etc. fabrication and application to refractive index and chemical sensing application

Module IV
Interferometric FOS basic principles, interferometric configurations- component, and construction of interferometric FOS - Mach-Zehnder, Michelson, Sagnac & fiber gyro-open loop and closed loop biasing scheme, Fabry-Perot configurations – application of interferometric FOS examples Optical microcavities, Whispering Gallery Modes in Optical microcavities, Passive and Active WGM microcavities, Polymer optical fiber based WGM microcavities, WGM Microcavities based sensors. Photonic crystals and photonic crystal fiber sensors, fiber loop ringdown spectroscopy

Experiential Learning:
Michelson, Mach Zehnder fiber optic sensors (using 3 dB couplers) , Whispering gallery mode sensing using optical microcavities.

References

1. Optical Networks: A Practical Perspective 3rd Edition, R Ramaswamy and Kumar N. Sivarajan, Morgan Kaufmann Publishers, 2010, (Text).
2. WDM Optical Networks Concepts, Design and Algorithms, Sivaram Murthy and Mohan Guruswamy. Prentice Hall, 2001 (Text).
3. Understanding Optical Communications, by Harry J.R. Dutton (pdf version http://cs5517.userapi.com/u133638729/docs/3745fff272ed/Dutton_HJR_Understanding_Optical_Communications.pdf)

4. Optoelectronic Packaging (Wiley Series in Microwave and Optical Engineering), Alan R. Mickelson, Nagesh R. Basavanhally, Yung-Cheng Lee, Wiley Blackwell, 1997.
5. WDM Technologies: Active Optical Components, Volume 1, By Niloy K. Dutta, Masahiko Fujiwara, Academic Press, 2002.
6. Clean Assembly Practices to Prevent Contamination and Damage to Optics, J.Pryatel, W.H. Gourdin (pdf version available at https://e-reports-xt.llnl.gov/pdf/328839.pdf).
7. Advanced Optical Wireless Communication Systems, Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, and Murat Uysal, Cambridge University Press, 2012.
8. Optical Wireless Communications System and Channel Modelling, Z. Ghassemlooy W. Popoola S. Rajbhandari, CRC Press, 2019.

23-351-0607 Photonic Crystals and Optical Metamaterials

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Summarize the fundamental concepts of electromagnetic waves in periodic structures, including the Bloch theorem and photonic band structure.	Understand	6	3
CO2	Explain the concept of bandgap engineering in 2D and 3D Photonic crystals, understanding how it influences the optical properties.	Understand	5	4
CO3	Apply the mixing rules to analyze the macroscopic effective parameters of metamaterials, considering the optical properties of metals and dielectrics.	Understand	6	3
CO4	Illustrate the optical magnetism in nature, examining the role of split-ring resonators in creating magnetic metamaterials.	Apply	6	4
CO5	Explain the principles of nonlinear optics with metamaterials.	Understand	5	3
CO6	Utilize the concepts of transformation optics to explain the electromagnetic cloak of invisibility.	Apply	6	3
CO7	Discuss the principles behind super resolution with meta-lenses, examining how these lenses achieve subwavelength resolution in optical imaging.	Understand	6	5
CO8	Evaluate the theoretical foundations and limitations associated with the concept of a perfect lens with subwavelength resolution.	Apply	5	5
	Total number of hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	3	1	1	2	
CO2	3	3	1	3	1	1	2	
CO3	3	3	1	3	1	1	2	
CO4	3	3	1	3	1	1	2	
CO5	3	3	1	3	1	1	2	
CO6	3	3	1	3	1	1	3	
CO7	3	3	1	3	1	1	3	
CO8	3	3	1	3	1	1	3	

3-High; 2-Medium; 1-Low

Module I

Photonic crystals: Electromagnetic waves in periodic structures-Matrix theory of dielectric layered media, Bragg Grating,1D Photonic crystals — Bloch modes, Dispersion relation and photonic band structure.

Real and reciprocal lattices; 2D and 3D Photonic crystals; Bandgap engineering; Devices based on photonic crystals; Emerging Applications of Photonic Crystals.

Module II

Metamaterials: Macroscopic Effective Parameters, Optical properties of metals and dielectrics, Metal-Dielectric Composites and Mixing Rules-electric metamaterials-Optical Properties of Stratified Metal-Dielectric Composites-Periodic Array of Metallic Wires-Semicontinuous Metal Films-Magnetic Metamaterials-Split-Ring Resonators.

Module III

Negative-Index Metamaterials-Reversed Phenomena in Negative-Index Media-Optical negative index materials-General Recipe for Construction-Nonlinear Optics with Metamaterials-Second-Harmonic Generation and the Manley–Rowe Relations in Negative-Index Materials-Optical Parametric Amplification in Negative-index Materials.

Module IV

Super Resolution with Meta-Lenses-Perfect Lens with Subwavelength Resolution.

Transformation Optics and Electromagnetic Cloak of Invisibility-Cloaking by Coordinate Transformation.

Experimental Techniques-Fabrication of Two-Dimensional Optical Metamaterials-Characterization of Spectral Properties.

References

1. Fundamentals of Photonics, 3rd Edition. by Bahaa E. A. Saleh, Malvin Carl Teich (2019).
2. Fundamentals and Applications of Nanophotonics. by Joseph W. Haus (2016).
3. Optical Metamaterials: Fundamentals and Applications, W. Cai and V. Shalaev Springer (2010).
4. Optical waves in layered media, Pochi Yeh, Wiley Interscience publication (1988).
5. Photonic crystals: moulding the flow of light, John Joannopoulos, Joshua N. Winn, and Robert D. Meade, Princeton University press, Second Edition (2008).

23-351-0608 Fourier Optics and Optical Signal Processing

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the fundamental concepts of signals.	Understand	8	
CO2	Explain the properties of linear systems.	Understand	7	
CO3	Illustrate the difference between Fraunhofer and Fresnel diffraction.	Understand	7	
CO4	Apply the principle of diffraction to specific examples.	Apply	8	
CO5	Utilize the Fourier transform property of the lens to predict image formation by a lens.	Apply	8	
CO6	Distinguish between coherent and incoherent imaging systems and their transfer functions.	Analyze	7	
CO7	Explain optical correlators and acousto-optic signal processing.	Understand	8	
CO8	Illustrate advanced pulse shaping and processing techniques.	Understand	7	
	Total hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1	1	
CO2	3	3	1	3	1	1	1	
CO3	3	3	1	2	1	1	1	
CO4	3	3	1	3	1	1	1	
CO5	3	3	1	3	1	1	1	
CO6	3	3	1	2	1	1	1	
CO7	3	3	1	3	1	1	1	
CO8	3	3	1	3	1	1	1	

3-High; 2-Medium; 1-Low

Module I

Signals: Characterization of a General signal, examples of signals, Spatial signal.

Linear Systems: Linearity and the Superposition Integral, Invariant Linear Systems, Transfer Functions.

General aspects of linear systems, Fourier transformation and spatial frequency spectrum, Linear space invariant and space variant systems. Sampling theory–Shannon-Whittaker sampling theorem, space-bandwidth product.

Module II

Fraunhofer and Fresnel diffraction, the Huygens-Fresnel Principle, Fresnel approximation, Positive and Negative Phases, Fourier transform in Fraunhofer diffraction. Examples of Fraunhofer diffraction- Rectangular aperture, Circular aperture.

Fresnel transform, Fresnel diffraction- square aperture, Fresnel propagation of a laser beam. Self imaging, Lau and Talbot effects.

Module III

Wave optics analysis of coherent optical systems. Thin lens as a phase transformation, the paraxial approximation, Fourier transform properties of lenses, different cases of image formation, Image formation in monochromatic illumination, lens law

Diffraction–limited coherent imaging, Fresnel zone plate, Operator approach to optical systems. Frequency response of diffraction-limited coherent imaging – the amplitude transfer function (ATF).

Optical Transfer Function (OTF), frequency response of a diffraction-limited incoherent imaging. Aberrations and their effects on frequency response. Comparison of coherent and incoherent imaging. Resolution beyond the diffraction limit.

Module IV

Optical Information Processing, Incoherent and Coherent Image Processing Systems, Optical Correlators, Acousto-Optic Signal Processing Systems, The Vanderlugt filter.

Pulse shaping and temporal processing, Holography and Diffractive Optics, Wave-front reconstruction, Computer Generated Holography.

References

1. Introduction to Fourier Optics, J. W. Goodman, McGraw-Hill. Third Edition, 2004
2. Statistical Optics, J. W. Goodman, Wiley Inter-science, 2000.
3. Fundamentals of photonics, Saleh and Teich, Wiley Interscience, 2007.
4. Optical signal processing, Anthony Vanderlugt, Wiley-Interscience

23-351-0701 Optoelectronics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Analyze the energy band structure of semiconductors to differentiate between direct and indirect bandgap materials.	Understand	4	4
CO2	Design basic circuits utilizing semiconductor principles, evaluating dynamic resistance and capacitance in pn junctions.	Apply	5	4
CO3	Evaluate LED materials, structures, and efficiencies to optimize luminous flux characteristics for various applications.	Analyze	5	6
CO4	Apply LED principles in optical fiber communications, designing circuits for efficient data transmission.	Apply	6	0
CO5	Apply the Shockley-Ramo theorem to assess external photocurrent in various photodetectors, considering noise characteristics.	Apply	5	4
CO6	Analyze the characteristics and applications of advanced photodetector technologies, such as avalanche photodiodes and pin photodiodes.	Evaluate	5	6
CO7	Assess the efficiencies and structures of various sensors and solar cells, optimizing performance for specific applications.	Analyze	5	6
CO8	Apply principles of optical computing, including QSD arithmetic and symmetric coding, in designing efficient computational systems.	Apply	10	0
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	2			3		
CO2	3	2					
CO3	3	2		2			
CO4	3	2		2			
CO5	3	2		1			
CO6	3	2		1			2
CO7	3	2		1			2
CO8	3	2		1			

3-High; 2-Medium; 1-Low

Module I

Review of semiconductor concepts and energy bands, Semiconductor statistics, Extrinsic semiconductors, Direct and indirect bandgap semiconductors, pn Junction principles, pn junction reverse current, pn junction dynamic resistance and capacitances, recombination lifetime, pn junction band diagram, Heterojunctions.

Module II

Light-emitting diodes: Principles, Homo junction and hetero junction LEDs, Quantum well LEDs, LED materials and structures, LED efficiencies and luminous flux, Basic LED characteristics, LEDs for optical fibre communications, Phosphors and white LEDs, LED electronics, Semiconductor lasers.

Module III

Principle of the pn Junction photodiode, Shockley-Ramo theorem and external photocurrent, Absorption coefficient and photodetector materials, Quantum efficiency and responsivity, The pin photodiode, Avalanche photodiode, Heterojunction photodiodes, Schottky junction photodetector, Phototransistors, Photoconductive detectors, Basic photodiode circuits, Noise in photodetectors.

Image sensors: CMOS and CCD.

Module IV

Photovoltaic devices: Solar cells, Basic principles, Operating current and voltage, and Fill factor, Equivalent circuit of a solar cell, Solar cell structures and efficiencies.

Optical computing: QSD arithmetic, Symmetric coding, Optoelectronic implementation, Artificial neural networks, Optical implementation of neural networks, Optical architecture for pattern association, Optical logic gates, Optical backplane buses, Binary memory cell and Optical switches.

References

1. Optoelectronics and Photonics: Principles and Practices (Second Edition), S O Kasap, Pearson 2023 (Text)
2. Optoelectronic Devices and Systems (Second Edition), S C Gupta, PHI Learning Pvt Ltd 2015 (Text)
3. Optoelectronics Sensors and Instrumentation, M K Ghosh, Ed-Tech New Delhi 2018.
4. Semiconductor Optoelectronic Devices (second edition), Pallab Bhattacharya, Pearson 2017.

23-351-0702 Condensed Matter Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe structural elements such as crystal planes and directions using standard notations.	Understand	8	0
CO2	Explain the concepts of reciprocal lattice and Brillouin zones.	Understand	7	0
CO3	Apply the theory of lattice vibrations to determine thermal properties of solids.	Apply	8	0
CO4	Understand the theory, properties and classification of superconductors and explain flux quantization and Josephson effects.	Understand	7	0
CO5	Explain the concept of density of states and occupation to determine macroscopic properties of solids.	Understand	5	0
CO6	Formulate the problem of electrons in a periodic potential, analyze electron dynamics in semiconductors and the effect of doping on the electronic properties of semiconductors.	Analyze	10	0
CO7	Outline the fundamental concepts of dielectric properties of materials- electric dipole moment electric flux density, polarizability and source of polarizability.	Understand	6	0
CO8	Understand magnetic properties of materials and classify magnetic materials based on magnetic susceptibility.	Understand	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3						
CO2	3	3						
CO3	3	3						
CO4	3	3						
CO5	3	3						
CO6	3	3						
CO7	3	3						
CO8	3	3						

3-High; 2-Medium; 1-Low

Module I

Crystal symmetry and crystal systems: translational vectors and lattices, unit cell, Miller indices, symmetry operations, reciprocal lattices, hexagonal close packed structure, NaCl, CsCl, diamond and ZnS structures, X-ray diffraction and Bragg's law, powder diffraction, different types of bonding in crystals, Vandervaal's, ionic, covalent , metallic and hydrogen bonds.

Module II

Lattice vibrations: phonons, phonon spectra of monatomic and diatomic linear lattices, scattering of phonons by neutrons, experimental techniques to get phonon spectra, lattice heat capacity, Einstein's Model, Debye's Model.

Superconductivity:experimental survey, type I and type II superconductors, Meissner effect, heat capacity, energy gap, isotope effect, thermodynamics of the superconducting transitions, London equation, coherence length, BCS theory of superconductivity, flux quantisation, Josephson effects, SQUID, high temperature superconductors.

Module III

Band theory of solids: density of states, Fermi level, origin of bands, Bloch theorem, Kronig-Penney model, classification of materials based on band gap, electrical conduction in metals and semiconductors, effect of doping on Fermi level in semiconductors.

Module IV

Dielectric properties of solids: polarisability, local electric field of an atom, ferroelectric crystals, Clausius Mossotti relation, Lorentz – Lorenz formula, Curie-Weiss Law, magnetic properties of solids, dia, para and ferro magnetism, Langevin's theory of diamagnetism and paramagnetism, ferromagnetic domains, hysteresis, B-H curve, adiabatic demagnetization.

References

1. Solid State Physics – C Kittel, 7 th edition, John Wiley (2004)(Text)
2. Introduction to Solids – Azaroff, Tata McGraw Hill (1977)
3. Text Book of Solid State Physics - S O Pillai, New age International (2002)
4. Problems in Solid State Physics - S O Pillai,New age International (2003)
5. Solid State Physics- A J Dekker, MacMillian India Ltd (2005)
6. Solid State Physics- M A Wahab,2nd edition,Narosa Publishing House Pvt. Ltd(2005)
7. Solid State Physics, N W Ashcroft, N David Mermin, Harcourt, (1976)

23-351-0703 Nonlinear Optics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concept of nonlinear susceptibilities, symmetries of nonlinear susceptibilities, index contraction and predict frequencies generated by nonlinear optical processes.	Apply	8	0
CO2	Analyze the theory of second order nonlinear effects - SHG, SFG DFG, OPO, Frequency Up/Down Conversion, principles of Phase-matching and Quasi Phase Matching conditions.	Analyze	7	0
CO3	Explain the concepts of Third order nonlinearity- third order susceptibility tensor, Degenerate four wave mixing.	Understand	9	0
CO4	Explain the theory behind Optical Phase Conjugation and its applications in image processing and distortion correction.	Understand	6	0
CO5	Explain the theory of nonlinear scattering mechanisms.	Understand	6	0
CO6	Understand the theories related to Self Focusing , Self Induced Transparency, and the propagation of optical solitons.	Understand	9	0
CO7	Explain the theory of nonlinear absorption processes - Saturable Absorption, Reverse Saturable Absorption, Two photon Absorption and its applications.	Understand	6	0
CO8	Analyze the theory of nonlinear Fabry-Perot etalon, optical bistability and its applications.	Analyze	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3						
CO2	3	3						
CO3	3	3						
CO4	3	3						
CO5	3	3						
CO6	3	3					2	
CO7	3	3					2	
CO8	3	3						

3-High; 2-Medium; 1-Low

Module I

Historical Overview of Nonlinear Optics, Non-linear polarization, physical origin of non-linear optical coefficients- Classical Anharmonic Oscillator Model, Miller's Rule, susceptibility tensors, Symmetries of nonlinear susceptibilities, Index contraction, d-matrix., Parametric and Non-parametric processes.

Propagation of EMW through nonlinear media, Coupled amplitude equations for second-order processes $\chi^{(2)}$, Phase Matching conditions, Quasi Phase Matching (QPM) , second harmonic generation, sum and difference frequency generation, optical parametric processes (OPA and OPO), Frequency Up/Down conversion.

Module II

Third order nonlinearity: Third order susceptibility tensor, Degenerate four wave mixing , Phase conjugate optics- properties of phase conjugate light,Generation of phase conjugate light, FWM in optical Kerr media, coupled mode formulation, Resonators with OPC mirror, Imaging through distorting medium.

Module III

Nonlinear scattering processes - Stimulated Raman Scattering (SRS)-Quantum mechanical description of Raman scattering, Raman cross section and gain, SRS described by non-linear polarization, Anti Stokes Raman Scattering, Coherent Antistokes Raman Scattering (CARS).
Self action effects- intensity dependent refractive index, Self-focusing effect, Self-induced transparency- pulse area theorem.

Module IV

Nonlinear absorption- Two photon Absorption (TPA), Multiphoton absorption, Applications of nonlinear absorption, saturable and reverse saturable absorbers, Z-scan theory of closed aperture and open aperture scan. Nonlinear Fabry- Perot etalon (NLF), NLF as a computing element, Optical Bistability, Optical logic gates.

References

1. Hand book of Nonlinear optics-Richard L Sutherland, (Second Edition), Marcel Dekker Inc,(2003) (Text).
2. Nonlinear optics- Robert W Boyd, Academic Press, Elsevier, Inc (Third Edition) (2008), (Text).
3. Photonics, Elemental and Devices- V V Rampal, Wheeler Publishing (1992).
4. Lasers and Nonlinear optics- B B Laud, Wiley Eastern 3rd Edition, (2004).
5. Optical Electronics in Modern Communications -A Yariv, Oxford University Press(5th Edition), (1997).
6. Nonlinear Optics- Y R Shen, John Wiley Sons (1991).
8. Nonlinear Fibre Optics- Govind P Agarwal, Academic Press, 4th Edition(2007).
9. Quantum Electronics- A Yariv, John Wiley Sons (1989).
10. Fundamentals of Photonics-B E A Saleh, M C Teich, John Wiley Sons, 2nd edition (2007).
11. Physics of nonlinear optics-Guang S He and Song H Lie, world scientific , London (1999).
12. Fundamentals of Nonlinear Optics- P.E.Powers , CRC Press(2011).

23-351-0706 Nanophotonics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe the basics of nanophotonics considering photon propagation under various interaction potentials.	understand	6	0
CO2	Explain the nanoscale optical interactions and apply nanoscale enhancement in near field optics and microscopy.	Apply	10	0
CO3	Explain the Quantum confinement effects in nanomaterials.	Analyze	8	0
CO4	Discuss nanostructural material behaviour and nanostructering techniques.	Analyze	8	0
CO5	Explain various methods of nano- structure fabrication.	understand	7	0
CO6	Characterization analysis of nanostructure size using experimental techniques.	Analyze	7	0
CO7	Explain nanoplasmonics and photonic band gap nanostructures.	Apply	7	0
CO8	Manipulate nanostructures to enhance secondary emission.	Analyze	7	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2			1	
CO2	3	3	1	1			1	
CO3	3	3	1	2			1	
CO4	3	3	1	1	1		1	
CO5	3	2	1	2	1		1	
CO6	3	3	1	2	1		1	
CO7	3	3	1	1			1	
CO8	3	3	1	1			1	

3-High; 2-Medium; 1-Low

Module I

Introduction to Nanophotonics – Breaking through diffraction limit, evanescent waves and optical near- field generation. Nanophotonics for real-time qualitative innovation.

Foundations of Nanophotonics- Photons and electrons- similarities and differences, Free-space propagation confinement of photons and electrons, propagation through classically forbidden zone: Tunnelling.

Localization under a periodic potential: bandgap, cooperative effects for photons and electrons, Nanoscale optical interactions: nanoscale confinement of electronic interactions, nanoscale electronic energy transfer, near-field interaction and microscopy, nanoscale enhancement of optical interactions.

Module II

Quantum confinement nature: Quantum well, Quantum wires, Quantum dots and Quantum rings. Manifestation of quantum confinement: modification of optical properties, semiconductor quantum dots, Quantum confined stark effects, Dielectric confinement effects.

Molecular nanotechnology and Quantum dot lasers.

Nano-structural material behaviour- nanoparticles, nano clusters, and nanocrystals. Nanomaterials and nano structuring techniques – Carbon nanotubes, single walled and multiwalled carbon nanotubes.

Module III

Manufacturing methods of nanomaterials: Top-down approach, Bottom-up approach, Combined Top-down and Bottom-up manufacturing.

Growth methods of Nanomaterials and nanoparticles – MBE, MOCVD, LPE, LAVD.

Characterization of Nanomaterials – X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), TEM, SEM, RHEED, EDS, SPM, STM.

Module IV

Nanoplasmonics: optical properties of metal-nano particles, size dependent absorption and scattering of coupled nanoparticles metal-dielectric core- shell nanoparticles, local electromagnetic fields in metal nanoparticles.

Photonic Crystals: Basic concepts: band gap and band structures in two and three dimensional lattices, periodic structures in nature, experimental methods of fabrication.

Plasmonic enhancement of secondary radiation: classification of secondary radiations, enhancement of emission and scattering of light, local density of states in plasmonic nanostructures.

Hotspots in plasmonic nanostructures, Raman-scattering enhancement in metal-dielectric nanostructures, luminescence enhancement in metal-dielectric nanostructures.

References

1. Nanophotonics- P N Prasad, Wiely Interscience(2003) (Text)
2. Principles of Nanophotonics- Motoich Ohtsu, KiyoshKohayish CRC Press (2012)
3. Nano materials Handbook- Ahemmed Bunaina, CRC Press , 2nd Edition (2009)
4. Nanostructured materials and Nanotechnology- Haro Singh Nalwa Academic Press (concise edition) USA (2002)

23-351-0707 Laser Spectroscopy

CO	**CO Statement**	**CL**	**Class Hrs**	**Lab Hrs**
CO1	Describe the importance of lasers in spectroscopy.	Understand	6	
CO2	Compare principles of photo acoustic and optothermal spectroscopy.	Analyze	6	
CO3	Enumerate the importance of ionization spectroscopy.	Analyze	8	
CO4	Discuss the difference between magnetic resonance and fluorescence spectroscopy.	Analyze	8	
CO5	Describe various multiphoton spectroscopic processes.	Understand	8	
CO6	Discuss the importance of Laser Raman Spectroscopy.	Understand	8	
CO7	Analyze various techniques to measure ultra short pulses.	Analyze	8	
CO8	Assess recent laser spectroscopic techniques for a particular use.	Evaluate	8	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2			1	
CO2	3	3	1	2			1	
CO3	3	3	1	2			1	
CO4	3	3	1	2			1	
CO5	3	3	1	2			1	
CO6	3	3	1	2			1	
CO7	3	3	1	2			1	
CO8	3	3	1	2			1	

3-High; 2-Medium; 1-Low

Module I

Advantages of lasers in spectroscopy, Frequency Modulation, Intra-cavity Laser Absorption Spectroscopy, Cavity Ring-Down Spectroscopy, Fluorescence Excitation Spectroscopy, Photoacoustic Spectroscopy, Optothermal Spectroscopy.

Module II

Ionization Spectroscopy – photo-ionization, collision-induced and field ionization, Sensitivity of ionization Spectroscopy, Pulsed versus CW Lasers for photo-ionization, resonant two-photon ionization combined with mass spectroscopy, optogalvanic spectroscopy, laser magnetic resonance and Stark spectroscopy, laser induced fluorescence spectroscopy

Module III

Linear and nonlinear absorption, saturation spectroscopy, Polarization spectroscopy, Multiphoton spectroscopy, two-photon absorption spectroscopy, Doppler-Free Multiphoton Spectroscopy, Experimental techniques of linear Laser Raman Spectroscopy, Nonlinear Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Resonant CARS and BOX CARS, Surface Enhanced Raman Spectroscopy

Module IV

Time resolved laser spectroscopy, Measurement of Ultrashort Pulses, Streak Camera, Optical Correlator for Measuring Ultrashort Pulses, FROG Technique, SPIDER Technique, Lifetime Measurement with Lasers, Spectroscopy in the Pico-to-Attosecond Range, Applications, Laser Induced Breakdown Spectroscopy, Laser Cooling and trapping of atoms, Fluorescence Correlation Spectroscopy, Optical Frequency Combs

References

1. Laser Spectroscopy Vol. 2 Experimental Techniques, Wolfgang Demtröder, Springer Berlin Heidelberg (2008) (Text)
2. Femtosecond Optical Frequency Comb: Principle, Operation and Applications, Jun Ye, Steven T Cundiff, Springer New York, 2010
3. Photoacoustics and Photoacoustic Spectroscopy, A. Rosencwaig, Wiley Interscience, New York, 1980
4. Laser cooling and trapping, H J Metcalf and P Straten, Springer New York, 1999

23-351-0708 Quantum Optics and Quantum Computing

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand quantized electromagnetic field and the origin of number states.	Understand	7	0
CO2	Illustrate the concept of coherent states and squeezed states.	Apply	8	0
CO3	Examine optical coherence, photon correlation, and photon statistics.	Apply	10	0
CO4	Summarize the squeezed light generation and applications.	Understand	5	0
CO5	Analyse the concepts of hidden variable, entanglement and interferometric measurements.	Analyze	9	0
CO6	Discover the interaction between atoms and quantised fields.	Analyze	6	0
CO7	Explain the concept of qubits and quantum gates.	Analyze	7	0
CO8	Classify various quantum algorithms and quantum hardware.	Analyze	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1		
CO2	3	3	1	2	1	2		
CO3	3	3	1	3	1	3		
CO4	3	2	1	3	2	1		
CO5	3	3	1	2	2	1		
CO6	3	3	1	3	3	3		
CO7	3	3	1	1	3	1		
CO8	3	2	1	1	3	1		

3-High; 2-Medium; 1-Low

Module I

Concept of density matrix and its properties: Quantization of EMF, Fock/Number states, Expansion in number states, Coherent States, Displacement operator, Squeezed States, Squeezing operator, Coherence properties of EMF: First order optical coherence, Photon correlation measurements, Hanbury Brown-Twiss experiments

Module II

Photon counting measurements, Classification of light by photon statistics, Photon bunching, Photon antibunching, Squeezed light: Generation and application of squeezed light, Resonant light atom interactions, Two level atom approximation, Rabi oscillations.

Module III

EPR argument, experimental studies, Bell's inequalities in quantum optics, nondemolition measurements, quantum coherence, Entanglement and interferometric measurements. Deflection of atoms by light, Kapitza- Dirac effect, Interaction between Atoms and quantized fields- dressed fields, Jaynes - Cummings model.

Module IV

Introduction to quantum bits (Qubits), Representation of qubits using Dirac notation, superposition and entanglement of qubits, basic quantum gates, no-cloning theorem and quantum teleportation, quantum algorithms, quantum computing hardware, applications of quantum computing.

References

1. Quantum Optics -D F Walls, G J Milburn Springer Verlag, 2nd edition (2008) (Text).
2. Quantum Optics an Introduction - Mark Fox Oxford University Press (2004) (Text).
3. Introduction to Quantum Optics From the Semi-classical Approach to Quantized Light, Alain Aspect , Claude Fabre , Gilbert Grynberg, Cambridge University Press, 2010, (Text).
4. Introductory Quantum Optics Christopher Gerry and Peter L knight, Cambridge University, 2004.
5. Quantum computing for everyone -Chris Bernhardt, MIT Press, Cambridge, 2019 (Text).
6. Quantum Computation and Quantum Information: 10th Anniversary Edition, Michael A. Nielsen & Isaac L. Chuang, MIT Press, Cambridge, 2011.
7. Optical Coherence and quantum optics, Leonard Mandel, Emil Wolf, Cambridge University Press, 2nd Edition (2013).
8. Fundamentals of Quantum Optics- John R Klauder and ECG Sudarshan, Dover publication (2006).
9. Quantum Optics- Werner Vogel, Dirk-Gunnar Welsch, Wiley VCH, 3rd edition (2006).

23-351-0709 Advanced Electromagnetic Theory

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the frequency dispersion characteristics of dielectrics, conductors, and plasma.	Understand	6	0
CO2	Apply the concepts of the dielectric function of metals to study their roles in defining phenomena like bulk, surface, and localized modes in small particles.	Apply	6	0
CO3	Understand the inhomogeneous electromagnetic wave equation.	Understand	4	0
CO4	Apply the knowledge of retarded fields to study the field of fast moving particles and the mechanism of radiation.	Apply	10	0
CO5	Illustrate electromagnetic scattering and antenna theory, including multipole expansion and Dyadic Green's functions, as well as their application in analyzing electric fields.	Understand	8	0
CO6	Apply Mie theory, antenna theory and Green's functions for the optical response of nanoscale structures.	Apply	8	0
CO7	Understand computational methods in electromagnetics, including analytical solutions and numerical techniques like FDTD and FEM.	Understand	8	0
CO8	Apply the analytical methods, FDTD and FEM to analyze electromagnetic response of simple systems.	Analyze	10	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	2	
CO2	3	2	1	1	2	1	2	
CO3	3	2	1	1	2	1	2	
CO4	3	2	1	1	2	1	2	
CO5	3	2	1	1	2	1	2	
CO6	3	2	1	1	2	1	2	
CO7	3	2	1	1	2	1	2	
CO8	3	2	1	1	2	1	2	

3-High; 2-Medium; 1-Low

Module I

Frequency dispersion characteristics of dielectrics, conductors and plasma, simple model of dispersion, anomalous dispersion and resonant absorption, low frequency behaviour and conductivity, high frequency behaviour and plasma frequency. Dielectric function of metals, Drude model, Interband transitions, bulk plasmons, surface modes, localized modes in metallic particles, excitation of the localized modes.

Module II

Inhomogeneous electromagnetic wave equation, Retarded potentials and fields of a continuous charge distribution, Lienard-Wiechert potentials and electric and magnetic fields for a moving point charge, electric dipole radiation, magnetic dipole radiation, radiation by an arbitrary source, radiation pattern and power radiated by a moving point charge, total power radiated by an accelerated charge: Larmor formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge, radiation reaction force.

Module III
Electromagnetic scattering and antennas: multipole expansion of potential, field of a dipole in coordinate-free form and plotting it using Octave, electric field due to a uniformly polarized sphere and plotting it using Octave. Dyadic Green's functions, plotting the electric near-field and far-field of a radiating dipole using Green's functions.
Rayleigh and Mie scattering, Mie modes, Mie modes in dielectric particles and their antenna properties.
Dipole antenna, fundamental antenna parameters, half-wave dipole, antenna array and diffraction. Antenna modes in metallic particles of simple geometry, dark and bright modes.

Module IV
Computational methods in electromagnetics: simple systems having analytical solutions, field of a homogeneous sphere placed in a quasi-static electric field, Finite Difference Time-Domain method (FDTD), Finite Element Method (FEM).

References

1. An Introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text).
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley, 1998 (Text).
3. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
4. Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Ed. Wiley, 2016 (Text).
5. Computational Electrodynamics: The Finite Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House 1995 (Text).
6. Computational Electromagnetics for RF and Microwave Engineering, David B Davidson, Cambridge University Press, 2011 (Text).
7. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson, Springer-Verlag, New York, 2013 (Text).

23-351-0807 Optomechanical Engineering

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the principles and materials required for opto-mechanical systems.	Understand	5	3
CO2	Understand basic drawings of optical components and systems.	Understand	6	3
CO3	Analyse the characteristics of the materials for opto-mechanical systems.	Analyse	5	4
CO4	Analyse the integrated tolerance	Analyse	6	4
CO5	Understand the design and mounting of small mirrors and lenses	Understand	6	4
CO6	Understand the various kinematic constraints in mounting	Understand	5	4
CO7	Model simple opto-mechanical mounts	Apply	6	4
CO8	Understand various methods of fabricating opto-mechanical mounts	Understand	6	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1		
CO2	3	3	1	2	1	2		
CO3	3	3	1	3	1	3	2	
CO4	3	2	1	3	2	1	2	
CO5	3	3	1	2	2	1	2	
CO6	3	3	1	3	3	3	2	
CO7	3	3	1	3	3	1		
CO8	3	2	1	3	3	1	2	

3-High; 2-Medium; 1-Low

Module I

Basic computerized drawing, drawings of optical components and systems, dimensional tolerances and error budgets. Principles of opto mechanical design-structural and kinematic aspects- vibration control. Materials properties and selection criteria.

Module II

Opto-Mechanical Characteristics of Materials: Materials for opto-mechanical systems - physical, mechanical, thermal properties, dimensional stability, hysteresis, Inhomogeneity and anisotropy, temporal stability, integrated tolerance analysis.

Module III

Design and Mounting of Small Mirrors and lenses, Surface contact mounting, stress variations with surface radius, preload, material, temperature, cemented and air space doublet, linear, tilt and rotary adjustment mechanisms, kinematic constraints and degrees of freedom, coupling methods, design guide lines.

Module IV
Analysis of the Opto-Mechanical Design Interface, structural analysis using Finite Element principles, modelling, analysis and optimization of simple opto-mechanical mounts, optimum design for minimum stress transfer, Fabrication methods.

References

1. Handbook of Optomechanical Engineering, Ahmad, Anees, CRC Press (2017).
2. Opto-Mechanical Systems Design, Volume 1_ Design and Analysis of Opto-Mechanical Assemblies, Paul Yoder, Daniel Vukobratovich, CRC Press (2015).
3. Optomechanical Systems Engineering, Keith J. Kasunic , Wiley (2015).

23-351-0808 Laser Systems and Laser Applications

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand about different type of laser systems.	Understand	8	0
CO2	Understand about classification of lasers.	Understand	7	0
CO3	Understand about laser welding.	Understand	7	0
CO4	Understand about material removal using lasers.	Understand	8	0
CO5	Understand about lasers in chemistry.	Understand	8	0
CO6	Analyze how lasers can be used to monitor ultrafast processes.	Analyze	7	0
CO7	Understand about holography.	Understand	7	0
CO8	Analyze applications of holography.	Analyze	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

Module I

Classification of lasers- two level, three level and four level laser systems.
He-Ne laser, Ar -ion laser, Kr- ion laser, He-Cd laser, Copper vapour laser, CO_2 laser, N_2 laser, Excimer laser, X-ray laser, FEL laser.

Module II

Industrial applications of lasers, Laser welding, laser surface treatments, laser-induced material removal- cutting, scribing, marking.

Module III

Lasers in chemistry- laser isotope separation, laser induced chemical reactions- IR photochemistry. Ultrafast processes in Bio-molecules-monitoring, fast chemical reactions, study of photochemical processes and stimulation photochemical reactions.

Module IV

Holography, Hologram recording and reconstruction, thin and thick holograms, applications of holography in NDT and pattern recognition.

References

1. Laser Fundamentals - William T Silfvast, Cambridge University Press, 2nd Edition(2008) (Text).
2. Laser Processing and Analysis of Materials- W WDuley , Plenum Press (1983)(Text).
3. Industrial applications of lasers- John F Ready, Accademic Press, USA, 2nd Edition, ISBN 0-12-583961-8 (1997)(Text).
4. Lasers, Principles , Types and Applications- K R Nambiar, New Age International Delhi (2004), (Text).
5. Laser picosecond Spectroscopy and photochemistry of Biomolecules, V S Letokhov(Ed.), Adam Hilger, Bristal and Philadelphia (1987).
6. Lasers and Non-linear optics – B B Laud, 3rd Edition, New Age International Private Limited, 2011.
7. Fundamentals of Photonics- B E Saleh , M Teich, John Wiley Sons 2nd Edition (2007).
8. Optical Holography- P Hariharan, Cambridge University Press, 2nd Edition (1996).
9. Lasers in Medicine – H K KCobener, Wiley Sons.
10. Laser Cooling and Trapping - H J Metcalf and P Van der Straten, Springer Verlag, (1999).
11. Optical computing – D G Beitelson , MIT Press, (2000).
12. Laser Processing and Chemistry- Dieter Bauerle, Springer Verlag, 3rd Edition (2000).
13. Wave Optics and its applications, R S Sirohi, Orient Longmann (2001).
14. Spectroscopy, Luminescence and radiation centre in minerals-A S Marfunin, Springer Verlag, NY (1997).
15. Luminescence in solids-DRVij, Plenum Press, New York (1998).

Solar Cells

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Demonstrate the knowledge of semiconductor physics for photovoltaic application.	Understand	6	6
CO2	Apply the principle of solar energy conversion and calculate the conversion efficiency.	Apply	6	6
CO3	Explain the basics of thin film solar cell.	Understand	5	0
CO4	Outline the principle on which dye sensitized solar cell works on and its fabrication using novel dyes.	Understand	6	6
CO5	Develop understanding of organic solar cell and BHJ solar cells.	Understand	5	0
CO6	Demonstrate the basics of perovskite solar cell and its principle and fabrication method	Understand	6	0
CO7	Understand the new field of research in solar cell by using nanomaterials and band gap engineering of these nanomaterials.	Understand	6	6
CO8	Apply the understanding of connection of solar PV modules and its design to analyze the PV module power output.	Apply	5	6
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2		1		
CO2	3	3	1	3		3		
CO3	3	3	1					
CO4	3	3	1	2		3		
CO5	3	3	1					
CO6	3	3	1					
CO7	3	3	1					
CO8	3	3	1	1		3		

3-High; 2-Medium; 1-Low

Module I

Fundamentals of solar PV cells and systems: semiconductors as basis for solar cells materials and properties, charge carrier generation and recombination, P-N junction, I-V characteristics of solar cells in dark and light, principle of solar energy conversion, conversion efficiency.

Module II

Crystalline silicon and III-V solar cells, thin film solar cells: amorphous silicon, quantum dot solar cells.

Dye Sensitized solar cells, fabrication of dye sensitized solar cells, design of novel dyes, design of solid electrolytes materials, counter electrode engineering.

Module III
Introduction to organic solar cells, bulk heterojunction (BHJ) solar cells, morphology and charge separation in BHJ, design of low bandgap polymers.
Perovskite Solar Cells, fabrication of perovskite solar cells, photophysics in perovskite solar cells, stability in perovskite solar cells.

Module IV
Nanomaterials for photovoltaics, PV panels with nanostructures, band gap engineering and optical engineering
Solar PV modules: series and parallel connections, mismatch between cell and module, design and structure, PV module power output

References

1. Solar Photovoltaics: Fundamental, Technologies and Application, Chetan Singh Solanki, Edition 3, PHI Learning Pvt. Ltd., 2015.
2. Introduction to Photovoltaics, John Balfour, Micheal Shaw, Sharlene Jarosek, Jones & Bartlett Publishers, 2012.
3. Dye-sensitized Solar Cells (Fundamental Sciences, Chemistry), Kuppuswamy Kalyanasundaram, EPFL Press, 1st edition, 2010.
4. Organic Solar Cells: Theory, Experiment, and Device Simulation, Wolfgang Tress, Springer Cham, 2014.
5. Perovskite Solar Cells: Properties, Application and Efficiency, Muruli Banavoth, Nova science publishers, 2019.
6. Nanostructured materials for solar cell application, Katsuaki Tanabe, MDPI books, 2022.

23-351-0901 Industrial Photonics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand various fiber optic components used in optical communication industry.	Understand	8	6
CO2	Understand the role of active optical components in optical communication.	Understand	6	
CO3	Understand different optical networking terminologies.	Understand	2	8
CO4	Understand various physical network topologies.	Understand	8	
CO5	Compare existing wireless access schemes.	Analyze	8	
CO6	Analyze the nature of optical wireless channel.	Analyze	8	
CO7	Analyze the role of various tools for fiber optic assembly.	Analyze	2	8
CO8	practice the use of fusion splicer to make permanent fibre joints.	Apply	3	8
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

Module I

Optical components for communication, theory and principles of operation, Directional couplers, Variable Optical Attenuator (VOA), Polariser, Polarisation controller, isolators, circulators, multiplexers, wavelength filters, fiber gratings, Arrayed Waveguide Grating (AWG), Dielectric Thin-Film Filters, Active Optical Components, Tunable light sources, Optical switches, Optical amplifiers.

Module II

Introduction to optical networks, Optical network evolution and concepts: Optical networking terminology, Optical network node and switching elements, Layers of optical network, SDH/SONET Layering, Frame structure, Physical network topologies, Network protection, Access networks, Passive Optical Networks, Optical Interconnects, Data Centers.

Module III

Existing wireless access schemes, Potential optical wireless communication (OWC) application areas, Optical sources, detectors, Nature of optical wireless channel, Hardware aspects of receiver-amplifier in the indoor channel environment, visible light communication, LiFi technology.

Module IV

Fiber Optic Assembly: Reliability requirements, Fiber Optic Standards, Assembly environment:- clean rooms, classification- Tools for Fiber optic assembly- strippers, cleavers-Instruments for test purpose- IL Meter, BR Meter, Optical Spectrum Analyzer, Optical power meters, OTDR, Fiber optic Sources- Fiber joints-connectors, splices, Fusion splicers-Fiber polishing-Fiber cable design and structures- Photonic Packaging-Passive and active component packaging.

References

1. Optical Networks: A Practical Perspective 3rd Edition, R Ramaswamy and Kumar N. Sivarajan, Morgan Kaufmann Publishers, 2010, (Text).
2. WDM Optical Networks Concepts, Design and Algorithms, 2002 – Sivaram Murthy and Mohan Guruswamy. Prentice Hall, 2001 (Text).
3. Understanding Optical Communications, by Harry J.R. Dutton (pdf version http://cs5517.userapi.com/u133638729/docs/3745fff272ed/Dutton_HJR_Understanding_Optical_Communications.pdf)
4. Optoelectronic Packaging (Wiley Series in Microwave and Optical Engineering), Alan R. Mickelson, Nagesh R. Basavanhally, Yung-Cheng Lee, Wiley Blackwell, 1997.
5. WDM Technologies: Active Optical Components, Volume 1, By Niloy K. Dutta, Masahiko Fujiwara, Academic Press, 2002.
6. Clean Assembly Practices to Prevent Contamination and Damage to Optics, J. Pryatel, W.H. Gourdin (pdf version available at https://e-reports-xt.llnl.gov/pdf/328839.pdf).
7. Advanced Optical Wireless Communication Systems, Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, and Murat Uysal, Cambridge University Press, 2012.
8. Optical Wireless Communications System and Channel Modelling, Z. Ghassemlooy W. Popoola S. Rajbhandari, CRC Press, 2019.

23-351-0904 Quantum Communication

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Analyze the principles of quantum tunnelling and its significance in quantum computing.	Analyze	7	0
CO2	Identify basic applications of the Bloch sphere in visualizing qubit states.	Apply	6	0
CO3	Apply knowledge of qubit metrics to analyze and interpret experimental results, such as spin relaxation time and decoherence time.	Apply	6	0
CO4	Discuss the practical implications of utilizing specific qubit modalities in quantum computing applications.	Analyze	8	0
CO5	Analyze quantum circuits for specific computational tasks, incorporating quantum gates and entanglement.	Analyze	7	0
CO6	Evaluate the significance of DiVincenzo's criteria in assessing the feasibility and effectiveness of quantum computation systems.	Evaluate	8	0
CO7	Describe the significance of the EPR paradox and density matrix formalism in quantum communication.	Understand	9	0
CO8	Demonstrate an understanding of basic principles underlying quantum communication protocols.	Understand	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2		1				
CO2	3	2		1				
CO3	3	2		1				
CO4	3	2		1				
CO5	3	2		1				
CO6	3	2		1				
CO7	3	2		1				
CO8	3	2		1				

3-High; 2-Medium; 1-Low

Module I

Quantum tunnelling, Stern and Gerlach experiment, Bloch sphere representation, Qubit rotations, Projective measurements, The vocabulary of quantum computing, Classical computers, Qbits and usability, Noisy intermediate scale quantum technology.

Module II

Qbit Metrics: Spin relaxation time, Dephasing time, Decoherence time, Hann echo, Ramsay experiment, Gate time, Gate fidelity.

Qbit Modalities: Trapped ion qubit, Superconducting transmons, Topological qubits, Quantum dots, Dilution refrigerator.

Module III

Quantum circuits, Quantum gates, The compute stage, Quantum entanglement, No-cloning theorem, Quantum teleportation, Quantum interference, Phase kickback, DiVincenzo's criteria for quantum computation.

Module IV

EPR paradox, Density matrix formalism, Von Neumann entropy, Entangled photons, Quantum communication, quantum channel, Quantum communication protocols, RSA security.

References

1. Fundamentals of Quantum Computing: Theory and Practice, V Kasirajan, Spinger Switzerland, 2021.
2. Quantum Computation and Quantum Information, Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press, 2010.
3. Quantum Information Theory and the Foundations of Quantum Mechanics, Christopher G. Timpson, Cambridge University Press, 2013.
4. Introduction to Topological Quantum Matter & Quantum Computation, Chetan Nayak, Steven H. Simon, Ady Stern, Michael Freedman, and Sankar Das Sarma, Cambridge University Press, 2013.

23-351-0905 Ultrafast Optics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Analyse the significance and applications of ultrashort laser pulses.	Analyze	7	0
CO2	Demonstrate proficiency in Electric Field Autocorrelation and Cross-Correlation Measurements for pulse analysis.	Apply	6	0
CO3	Evaluate advanced techniques like Frequency-Resolved Optical Gating for pulse characterization.	Apply	6	0
CO4	Analyze the effects of Group Velocity Dispersion on pulse propagation and optical components.	Analyze	8	0
CO5	Evaluate Ultrafast Nonlinear Optics phenomena, including Forced Wave Equation and Modulational Instability.	Analyze	7	0
CO6	Analyze Pump–Probe techniques for time-resolved spectroscopy.	Evaluate	8	0
CO7	Evaluate principles of Terahertz Time-Domain Electromagnetics, including pulse generation and spectroscopy.	Understand	9	0
CO8	Analyze Acousto-optic Dispersive Filters, understanding their advantages in pulse shaping.	Analyze	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1	1			
CO2	3	3	1	1			
CO3	3	3	1	1			
CO4	3	3	1	1			
CO5	3	3	1	1			
CO6	3	3	1	1			
CO7	3	3	1	1			
CO8	3	3	1	1			

3-High; 2-Medium; 1-Low

Module I

Introduction to ultrashort laser pulses: significance and application of ultrashort pulses, overview of ultrashort pulse generation techniques. Introduction to Ultrashort Pulse Generation Through Mode-Locking.

Solid-State Laser Mode-Locking Using the Optical Kerr Effect: Nonlinear Refractive Index Changes, Self-Amplitude Modulation, Self-Phase Modulation, and Group Velocity Dispersion, Additive Pulse Mode-Locking, Kerr Lens Mode-Locking

Module II

Ultrashort Pulse measurement method: Electric Field Autocorrelation Measurements, Electric Field Cross-Correlation Measurements and Spectral Interferometry. Correlation Measurements Using Second-Harmonic Generation, Chirped Pulses and Measurements in the Time–Frequency Domain. Frequency-Resolved Optical Gating and Pulse Measurements, Pulse Measurements Based on Frequency Filtering.

Module III

Group Velocity Dispersion, Dispersion of Optical Components, Measurements of Group Velocity Dispersion.

Ultrafast Nonlinear Optics: Forced Wave Equation in Frequency and Time Domain, SHG with pulse, three wave interaction, propagation equation for nonlinear refractive index media, Self-Phase modulation, pulse compression, Modulational instability, solitons and Higher order propagation effects.

Module IV

Fourier Transform Pulse Shaping, Direct Space-to-Time Pulse Shaping, Acousto-optic Dispersive Filters and their advantages. Chirp Processing and Time Lenses, Ultrashort-Pulse Amplification. Ultrafast Time-Resolved Spectroscopy: Degenerate Pump–Probe Transmission Measurements, Nondegenerate and Spectrally Resolved Pump–Probe. Generation and Measurement of Terahertz Pulses, Terahertz Spectroscopy and Imaging

References

1. Ultrafast Optics by Andrew Weiner (John Wiley & Sons, 2009) (Text).
2. Principles of Lasers by Orazio Svelto (5th ed., Springer, 2010).
3. Nonlinear Optics by Robert Boyd (3rd ed., Academic Press, 2008).
4. Ultrafast Optics by Franz X. Kärtner (from MIT course 6.638 offered in Fall 2008).

23-351-0906 Plasma Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the concept of plasma parameters.	Understand	6	
CO2	Analyse the dynamics of charged particle in Electric and magnetic field.	Analyze	6	
CO3	Discuss the drift of charged particles under combinations of fields.	Understand	8	
CO4	Explain the dynamics of charged particles under time varying fields.	understand	8	
CO5	Illustrate the kinetic and fluid description of plasma.	Analyze	8	
CO6	Explain plasma instabilities and its classification.	Understand	8	
CO7	Discuss the technical application of plasma.	Understand	8	
CO8	Explain the laser produced plasma and its diagnostics.	Understand	8	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

Module I

Plasma State: Definition of Plasma, concept of plasma temperature, Debye shielding, quasineutrality, plasma parameters, plasma approximation, natural existence of plasma, application of plasma, dynamics of charged particles in electro-magnetic fields.

Module II

Drift of charge particle under different combination of electric and magnetic field, crossed electric and magnetic field, homogeneous electric and magnetic field spatial and time varying electric and magnetic field.

Module III

Kinetic theory of Plasma, Vlasov equations, solution of linearized Vlasov equation, Langmuir waves, Ion-sound waves, wave-particle interaction and Landau damping. Boltzmann equation, Saha equation, Boltzmann's H Theorem.Maxwell velocity distribution conducting fluids, fundamental equation of magneto hydrodynamics (MHD), magnetic confinement, Plasma instabilities and classification.

Module IV

Thermonuclear fusion, Requirements for fusion plasmas- confinement, Tokamak fusion reactors, dusty plasma in laboratory and space, waves in dusty plasma. Laser plasma interaction, Inertial confinement, High-harmonic generation, Laser wakefield electron accelerator, X-ray laser.

References

1. Fundamentals of Plasma Physics, J A Bittencourt, Third Edition, Springer, New York, 2004 (Text).
2. Introduction to Plasma Physics and Controlled Fusion, Francis F Chen, Second Edition, Plenum, New York ,1984 (Text).
3. Fundamentals of Plasma Physics, Paul M Bellan, Cambridge University Press, 2006.
4. Introduction to Plasma Theory, D R Nicholson, John Wiley & Sons, New York, 1983.
5. The Physics of Laser Plasma Interaction, W L Kruer, Cambridge University Press, 1988.

23-351-0907 Microscopic Techniques

CO	**CO Statement**	**CL**	**Class Hrs**	**Lab Hrs**
CO1	Understand the basic concepts of instrumentation of optical microscopy.	Understand	7	
CO2	Evaluate the designs and specifications of different elements of an optical microscope.	Analyze	8	
CO3	Interpret phase contrast, dark-field, and polarization microscopy.	Understand	7	
CO4	Analyze confocal, two-photon, multi-photon and laser scanning microscopic techniques.	Analyze	8	
CO5	Compare super-resolution microscopy techniques for enhanced resolution and application-specific selection.	Apply	8	
CO6	Analyze classical resolution limits and apply super-resolution principles to specific microscopy techniques.	Analyze	7	
CO7	Understand resolution, electron-matter interaction, and instrument limitations of electron microscopes.	Understand	7	
CO8	Apply scanning probe microscopy basics, demonstrating understanding of electron tunneling, atomic forces, and their application on surfaces.	Apply	8	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1	2	
CO2	3	3	1	2	1	1	2	
CO3	3	3	1	2	1	1	3	
CO4	3	3	1	2	1	1	3	
CO5	3	3	1	2	1	1	3	
CO6	3	3	1	2	1	1	3	
CO7	3	3	1	2	1	1	2	
CO8	3	3	1	2	1	1	3	

3-High; 2-Medium; 1-Low

Module I

Optical components of a light microscope, aperture and image plane, Koehler illumination, microscope illuminators, filters, effect of light on living cells, designs and specifications of objective lenses, condensers, oculars, microscope slides and cover slips.

Diffraction image of a point source of light, Abbe's theory of image formation in the microscope, numerical aperture, spatial resolution, depth of field and depth of focus, optimizing the microscope image.

Module II

Phase contrast microscopy: the behaviour of waves from phase objects in bright-field microscopy, the role of differences in optical path lengths, optical design of the phase contrast microscope, interpreting the phase contrast image.

Dark-field microscopy: theory, image interpretation

Polarization microscopy: optics of the polarizing microscope, retardation plates, Sénarmont compensator, Brace-Koehler compensator.
Fluorescence Microscopy: physical basis of fluorescence, properties of fluorescent dyes, autofluorescence of endogenous molecules, arrangement of filters and the epi-illuminator, objective lenses and spatial resolution.
Confocal microscopy: optical principle of confocal imaging, advantages of confocal laser scanning microscopy.
Two- and multi-photon laser scanning microscopy.

Module III
Super resolution microscopy: classical resolution limit, near-field optical microscopy, I^5M microscopy, 4Pi microscopy, stimulated emission depletion (STED) microscopy, structured illumination spectroscopy, photoactivated localization microscopy (PALM), stochastic optical reconstruction microscopy (STORM), and fluorescent photoactivation localization microscopy (FPALM).

Module IV
Transmission and scanning electron microscopy: use of electrons for microscopy, resolution, interaction of electron with matter, depth of field and depth of focus, limitations of TEM, STEM, basic TEM instrumentation.
Scanning probe microscopy: basic principles, electron tunnelling, principles of atomic forces, theory of scanning tunnelling microscopy, metal and semiconductor surfaces.

References

2. Fundamentals of Light Microscopy and Electronic Imaging, Douglas B. Murphy and Michael W. Davidson, second edition, Wiley-Blackwell, 2013.
3. Transmission Electron Microscopy: A Textbook for Materials Science, David B. Williams and C. Barry Carter, Springer; 2nd edition, 2009.
4. https://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html.
5. Super resolution microscopy, Udo J. Birk, Wiley-VCH, 2017.
6. https://www.frontiersin.org/articles/10.3389/fchem.2021.746900/full.
7. Super resolution optical microscopy: The quest for enhanced resolution and contrast, Barry R. Masters, Springer Series in Optical Sciences, 2020.
8. Scanning probe microscopy and spectroscopy: theory, techniques, and applications second edition, edited by Dawn A. Bonnell, Wiley-VCH, 2001.