INTERNATIONAL SCHOOL OF PHOTONICS

COURSE STRUCTURE AND SYLLABUS
(OBE)

FOR

MASTER OF SCIENCE
(5 YEAR INTEGRATED)
IN
PHOTONICS

(2020 Admission onwards)

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI - 682022

Vision

To be an Institute of Eminence creating global leaders and innovators in the emerging field of light based technologies to meet the social challenges of today and the future.

Mission

To impart quality education that equip students through rigorous training towards meeting the needs of society and industry.

To provide state-of-the-art facilities to undertake research activities relevant to light based industries and promote entrepreneurship.

To collaborate with premier academic and research institutes around the globe to fortify the education and research environment.

Program Educational Objectives (PEOs)

PEO1: Inculcate advanced knowledge in photonics and apply theories and principles of general physics and optics in the domain of photonics.

PEO2: Acquire essential laboratory skills in general physics, electronics and advanced optics by designing experiments, carrying out measurements and analyzing acquired data.

PEO3: Provide professional consultancy and research support to photonics and optoelectronics industry and research organizations.

PEO4: Equip for inter-disciplinary & multi-disciplinary research and to be a life-long learner.

PEO5: Inculcate, socially responsible, value based and ethical leadership qualities in the professional and personal life.

Program Outcomes (POs)

PO1 : Gain sufficient knowledge in the areas of mechanics, mathematics, electronics, electrodynamics, quantum mechanics, statistical mechanics, optics, and laser technology.

PO2: Explain the advances in optical technology.

PO3: Expertise in communication, science writing skills and scientific presentations.

PO4: Develop proficiency in experimental skills, data acquisition and interpretation in the advanced topics of physics and optics.

PO5: Gain knowledge in computer simulation of photonic structures and numerical modelling.

PO6: Acquire sufficient skills in experimental designs and problem solving by carrying out minor and major projects in the advanced topics of photonics.

PO7: Familiarise the usage of modern and complex tools used in photonics research.

PO8: Address the societal needs through outreach programmes.

COURSE STRUCTURE

SEMESTER I

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0101	Mechanics	3		1	3	50	50	100
20-351-0102	Electricity and Magnetism	3		1	3	50	50	100
20-351-0103	Optics-I Geometrical Optics	3		1	3	50	50	100
20-351-0104	Mathematics I	3		1	3	50	50	100
20-351-0105	Statistical Methods	3		1	3	50	50	100
20-351-0106	Lab + Viva		6		3	100+ 50		150
20-351-0107	Communicative English	2		1	2	50	50	100
Total for Semester I		**17**	**6**	**6**	**20**	**450**	**300**	**750**

CA – Continuous Assessment
SEE- Semester End Examination

SEMESTER II

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0201	Electronics-I Basic Electronics	3		1	3	50	50	100
20-351-0202	Optics-II Physical Optics	3		1	3	50	50	100
20-351-0203	Mathematics-II	3		1	3	50	50	100
20-351-0204	Thermodynamics and Thermal Physics	3		1	3	50	50	100
20-351-0205	Nuclear and Particle Physics	3		1	3	50	50	100
20-351-0206	Lab+Viva		6		3	100+50		150
20-351-0207	History of Science and Technology	2		1	2	50	50	100
Total for Semester II		**17**	**6**	**6**	**20**	**450**	**300**	**750**

SEMESTER III

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0301	Electronics II Analog Electronics	3		1	3	50	50	100
20-351-0302	Classical Mechanics	3		1	3	50	50	100
20-351-0303	Optics III- Optical Instrumentation	3		1	3	50	50	100
20-351-0304	Mathematics III	3		1	3	50	50	100
20-351-0305	Atomic Spectroscopy	3		1	3	50	50	100
20-351-0306	Lab+Viva		6		3	100+50		150
20-351-0307	Seminar	1		0	1	50		50
Total for Semester III		**16**	**6**	**5**	**19**	**450**	**250**	**700**

SEMESTER IV

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0401	Electronics III Digital circuits and Microprocessors	3		1	3	50	50	100
20-351-0402	Statistical Mechanics	3		1	3	50	50	100
20-351-0403	Quantum Mechanics I	3		1	3	50	50	100
20-351-0404	Electromagnetic Theory and Relativistic Phenomena	3		1	3	50	50	100
20-351-0405	Mathematics IV	3		1	3	50	50	100
20-351-0406	Lab+ Viva		6		3	100+50		150
20-351-0407	Workshop		2	0	1	100		100
20-351-0408	Seminar	1			1	50		50
Total for Semester IV		**16**	**8**	**5**	**20**	**550**	**250**	**800**

SEMESTER V

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0501	Optics IV - Applied Optics	3		1	3	50	50	100
20-351-0502	Electronics-IV Electronic Instrumentation	3		1	3	50	50	100
20-351-0503	Quantum Mechanics II	3		1	3	50	50	100
20-351-0504	Materials Science	3		1	3	50	50	100
20-351-0505	Molecular Spectroscopy	3		1	3	50	50	100
20-351-0506	Lab+Viva		6		3	100+50		150
20-351-0507	Seminar	1			1	50		50
Total for Semester V		**16**	**6**	**5**	**19**	**450**	**250**	**700**

SEMESTER VI

Course Code	Course Title	Hours per week			Credit	Marks		
		Lecture	Lab	Tutorial		CA	SEE	Total
20-351-0601	Photonics-I Optoelectronics	3		1	3	50	50	100
20-351-0602	Photonics-II Fiber Optics	3		1	3	50	50	100
20-351-0603	Photonics-III Laser Physics	3		1	3	50	50	100
20-351-0604	Mathematical Modeling and Computational Techniques	3		1	3	50	50	100
20-351-0605	Project & Project Viva		9		3	100+50		150
20-351-0606	Computer Lab + Viva		6		3	100+50		150
Total for Semester VI		**12**	**15**	**4**	**18**	**500**	**200**	**700**
Total for Semester I-VI					**116**			**4400**

*** Project guidance of 9 hours shall be considered as equivalent to 3 lab hours per project for workload calculation**

SEMESTER VII

(Course Code of electives **20-351-0X2X** correspond to course code of electives chosen from the list of electives in each semester. For example, if Advanced Quantum Mechanics and Nanophotonics are offered as the Elective I and Elective II respectively in the VII semester then 20-351-0X2X will be 20-351-0721 and 20-351-0723, respectively)

Course Code	**Course Title**	**Hours per week**			**Credit**	**Marks**		
		Theory	**Lab**	**Tutorial**		**CA**	**SEE**	**Total**
20-351-0701	Advanced Solid State Theory	4		1	4	50	50	100
20-351-0702	Laser Systems	4		1	4	50	50	100
20-351-072X	Elective I	3		1	3	50	50	100
20-351-072X	Elective II	3		1	3	50	50	100
20-351-0703	Lab I Photonics Lab I		4		2	100		100
20-351-0704	Lab II Electronics Lab I		4		2	100		100
20-351-0705	Seminar + Viva	1			1	50+50		100
Total for Semester VII		**15**	**8**	**4**	**19**	**500**	**200**	**700**

SEMESTER VIII

Course Code	Course Title	Hours per week			Credit	Marks		
		Theory	Lab	Tutorial		CA	SEE	Total
20-351-0801	Nonlinear Optics	4		1	4	50	50	100
20-351-0802	Digital Signal Processing and Optical Signal Processing	4		1	4	50	50	100
20-351-082X	Elective III	3		1	3	50	50	100
20-351-082X	Elective IV	3		1	3	50	50	100
20-351-0803	Lab I Photonics Lab II		4		2	100		100
20-351-0804	Lab II Electronics Lab II		4		2	100		100
20-351-0805	Seminar + Viva	1			1	50+50		100
Total for Semester VIII		**15**	**8**	**4**	**19**	**500**	**200**	**700**

SEMESTER IX

Course Code	CourseTitle	Hours per week			Credit	Marks		
		Theory	Lab	Tutorial		CA	SEE	Total
20-351-0901	Optical Communication	4		1	4	50	50	100
20-351-0902	Lab I Photonics Lab III		4		2	100		100
20-351-0903	Lab II Computational Photonics Lab		4		2	100		100
20-351-0904	Seminar + Viva	1			1	50+50		100
20-351-092X	Elective V	3		1	3	50	50	100
20-351-092X	Elective VI	3		1	3	50	50	100
20-351-092X	Elective VII	3		1	3	50	50	100
Total for Semester IX		**14**	**8**	**4**	**18**	**500**	**200**	**700**

SEMESTER X

Course Code	Course Title	Hours per week			Credit	Marks		
		Theory	Lab	Tutorial		CA	SEE	Total
20-351-1001	Project & Project Viva				16	200+ 100	200+ 100	600
TOTAL for Semester X					**16**	**300**	**300**	**600**

*** Project guidance of tenth semester shall be considered as equivalent to 6 lab hours (per project) for workload calculation**

LIST OF ELECTIVES

Semester	Course Code	Course Title
VII	20-351-0721	Advanced Quantum Mechanics
	20-351-0722	Advanced Electromagnetic Theory and Computational Methods
	20-351-0723	Nanophotonics
	20-351-0724	Optical Sensor Technology
VIII	20-351-0821	Quantum Optics
	20-351-0822	Biophotonics
	20-351-0823	Optomechanical Engineering
IX	20-351-0921	Industrial Photonics
	20-351-0922	Photonic Bandgap Structures and Metamaterials
	20-351-0923	Holography and Speckle Metrology
	20-351-0924	Laser Spectroscopy
	20-351-0925	Computational Material Science

Total Credits for the Programme

Semesters	Credits	Marks		
		CA	SEE	Total
VII-X	72 (Core 51 and Electives 21 credits)	1800	900	2700
I-VI	116	2850	1550	4400
I-X	188	4650	2450	7100

20-351-0101 MECHANICS

Course Outcomes

On successful completion of the course, the student will be able to

1. Describe inertial and non-inertial frames of references (Understand)
2. Explain kinetic and potential energies under conservative and non-conservative forces (Understand)
3. Explain the conservation of linear and angular momentum(Understand)
4. Outline various fluid properties like viscosity and surface tension (Understand)
5. Relate special theory of relativity and Lorentz transformation(Understand)
6. Build energy-momentum relation under relativistic condition (Apply)

Module 1

Frames of reference, Laws of Mechanics, Inertial frames of reference, Galilean transformation, Galilean invariance, Conservation of momentum, Non-inertial frames and fictitious force, Centripetal force, Centrifugal force, Rotating frame of reference, Foucault's pendulum.

Module 2

Work and Power, Work-Energy theorem, Conservative forces, Potential Energy, Conservation of energy for a particle, Motion of a body near the surface of the Earth, Linear restoring force, Potential energy curve, Harmonic oscillator, Non-conservative forces, Motion under friction.

Module 3

Conservation of linear momentum, Centre of mass, Collision of two particles, Impact, Angular momentum and torque, Areal velocity, Examples of conservation of angular momentum.

Viscosity, Critical velocity, Flow of liquid through a capillary tube; Molecular forces, Surface tension, Shape of drops.

Module 4

Michelson-Morley experiment, Ether hypothesis, Special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity, addition of velocities, Relativistic Doppler's effect, Conservation of momentum and variation of mass, Relativistic energy, Relation between momentum and energy and conservation laws, Transformation of momentum and energy, Particle with zero rest mass,

References:

1. Mechanics, J C Upadhyaya, Ram Prasad and Sons (2001) (Text)
2. Mechanics D S Mathur, S Chand & Company (2007) (Tex)
3. Mechanics: Berkeley Physics Course, McGraw Hill Education; 2 edition (2017)
4. Feynman Lectures Vol I, Narosa Publishing House (2008).
5. Principles of Physics, Robert Resnick, David Halliday, 11th Edn. John Wiley & Sons (2018)

20-351-0102 ELECTRICITY AND MAGNETISM

Course Outcomes

On successful completion of this course, students will be able to:

1. Discuss the fundamental laws governing static electric fields and its implementation for to practical uses.(Understand)
2. 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)
3. Explain the fundamentals of alternating currents.(Understand)
4. Employ the basic circuit laws and DC network theorems in the analysis of electrical circuits. (Apply)
5. Identify the behaviour of combination of circuit elements across single phase AC supply. (Analysis)
6. Examine the phenomenon of series and parallel resonance in single phase AC circuits.(Analysis)
7. Describe operating principle of practical electrical devices.(Understand)

Module 1

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 2

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 3

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 4

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-6Th edition, Ratna Prakashan Mandir, Educational & University Publication, Barya ganj, New Delhi(2006).
4 Basic Electrical Engineering - volume 18Th edition,Thereja, S. Chand limited (2005).
5 K.K.Tewari, Electricity & Magnetism with electronics -7th 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, 2nd Revised Edition, NewYork, Mc Graw Hill Science 2017

20-351-0103 OPTICS I - GEOMETRICAL OPTICS

Course Outcomes

After completing the course the students will be able to

1. Describe the different methods for measuring the velocity of light. (*understand*)
2. Explain laws of reflection and refraction using Fermat's principle. (*understand*)
3. Distinguish normal and anomalous dispersion.(*understand*)
4.Explain different type of aberrations in lenses. (*understand*)
5. Apply matrix method to derive thick lens and thin lens formula.(*Apply*)
6.Discuss the construction and working of compound microscope and optical telescope.*(understand*)

Module 1

Nature of light, Light as waves, rays and photons, Refractive index, velocity of light. Foucault's, Anderson's, Houston's and Kerr cell methods to measure velocity of light. Photometry- Radiometric and Photometric units, inverse square law, Lambert's Law, Lummer, Flicker and photovoltaic photometers.

Module 2

Fermat's principle, Laws of reflection and refraction form Fermat's Principle, Total internal Reflection, Prism, Minimum deviation, achromatism in prisms, dispersion without deviation, normal and anomalous dispersion, Wood's experiment.

Module 3

Refraction and Reflection by spherical surfaces, Thin lens, converging, diverging and cylindrical lenses, Lens equations, aplanatic points, Combination of lenses, F number of a lens, Power of a lens. Aberrations-Spherical aberration, coma, astigmatism, distortion, chromatic aberration.

Module 4

Matrix methods in Optics- Paraxial rays, Matrix representation of translation, refraction, reflection of light rays, ABCD law, lens wave guide.
Spectrometer, Prism, Spectrograph, Telescopes-Resolving power, Types of telescopes, optical telescope, radio telescopes, Microscopes-Resolving power and magnifying power.

References

1. A text book of Optics N Subrahmaniam and BrijLal, M N Avadhanulu, S Chand and Company , 23rd Edition,(2006)(Text)
2. Optics, AjoyGhatak, 6thEdition,TataMc Grow Hill, (2017)
3. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013)
4. Optics, Eugune Hecht and A R Ganesan , 4th Edition, Pearson Education (2008)
5. Feynman Lectures Vol I - Narosa Publishing House (2003)
6. Optics, Sathyaprakash, PragatiPrakashan-Meerut (2011)

20-351-0104 MATHEMATICS I

Course outcomes

After completing the course the students will be able to

1. Understand differentiation of hyperbolic and inverse hyperbolic functions (Understand)
2. Understand integral calculus (Understand)
3. Examine Laplace, Helmholtz and Poisson equations (Analysis)
4. Analyze Bernoullis equations (Analysis)
5. Understand applications of differentiation and integration (Understand)

Module 1

Differential calculus: Differentiation of hyperbolic and inverse hyperbolic functions. Statement and applications of Leibnitz theorem, LMV theorem, Taylor's and Mclaurin's theorems (no proof). Application to expansion functions- L'Hospital's Rule and its applications. Partial differentiation Partial derivatives and total differential coefficients. Euler's theorem on homogenous function (no proof) chain rule for partial derivatives, errors and approximations.

Module 2

Integral calculus Integration by parts, definite integral, multiple integrals. Applications of differentiation and integration Equations of lengths of tangents, normal, radius of curvature, envelopes, rectification of curves. Volume of a solid of revolution, areas of surface of revolution.

Module 3

Ordinary Differential equations First order equation, variables separable, homogeneous and no homogeneous equations, integrating factor, Bernoulli's equations, enact equations, second order linear differential equations with constant coefficients. Complimentary function and particular integral, solution using auxiliary equation.

Module 4

Partial differential equations Derivation of PDE by elimination of arbitrary constants and arbitrary coefficients. Concept of Jacobian. Solution of Lagrange's Differential equations, Partial differential equation of the second degree, Laplace, Helmholtz and Poisson equations.

References

1. Calculus Vol I & Vol II Manicavachgom Pillai, Vishwanathan Publishing Co.,(2000) (Text)
2. Differential Calculus Shanti Narayan, Vishwanathan Publishing Co.,(2000) (Text)
3. Differential Calculus Joseph Edwards, AIIBS Publishers,(2001)
4. Integral Calculus for beginners, Joseph Edwards ,MacMillan and Co (2008)
5. Mathematical Methods for Physicists G B Arfken, H I Weber, Academic Press, (2001)
6. Mathematical Methods in Classical & Quantum Physics Tulsi Das, S K Sharma, University Press (2009)

20-351-0105 STATISTICAL METHODS

Course Outcomes

After completion of this course the student should be able to

1. Explain probability space, random variables and its various properties (Understand)
2. Apply the principle of least squares in curve fitting problem (Apply)
3. Differentiate various types of statistical distributions (Analyze)
4. Differentiate chi-squre, t and F distributions (Analyze)
5. Recognize the time series.(Remember)
6. Compute the most powerful test for testing simple null hypothesis against simple alternative. (Apply)

Module 1

Probability spaces : conditional and independence, random variables and random distributions, marginal and conditional distributions
Curve fitting and principle of least squares, linear and quadratic curves, simple linear regression and correlation.

Module 2

Independent random variables, mathematical expectation, mean and variance, binomial, Poissons and normal distributions, law of large numbers.

Module 3

Central limit theorem (no proof), sampling distribution and test for mean using T-distribution, c^2 and F distributions.

Module 4

Time series analysis, Stationarity and nonstationarity, autocorrelation function
Testing statistical hypothesis significance level, Neyman-Pearson theorem (no proof) and some of its simple applications, large sample test, standard error, tests based on T, c^2 and F.

REFERENCES

1 Statistical Methods S P Gupta, S Chand & Co. (Text)
2. Probability and Statistics for Engineering and Sciences J LDevore, Brooks, California(1987) (Text)
3 Probability and Statistics, Schaum Series, McGraw Hill (2004)
4. Fundamentals of Mathematical Statistics S C Gupta and V K Kapoor, S Chand & Co.
5. Time series analysis G E P Bor, G M Jenkins

20-351-0107 COMMUNICATIVE ENGLISH

Course Outcomes

On successful completion of the Course Modules the student should be able to

1. communicate with clarity, correctness and coherence
2. take part effectively in group discussions and present their views in a logical and convincing way.
3. comprehend, analyze and interpret technical articles and research papers.
4. acquire proficiency in writing technical articles, reports, research papers and proposals
5. make effective presentation using supporting facts, evidences and graphic aids

Module 1

Practical Communicative Skills- Focus on various methodologies and practicessuch as listening, speaking, reading and writing to improve primary communicative skills. In the process basic English grammar compatibility is ensured to enable use of vivid, lucid and mistake- free language.

Module 2

Vocabulary Building- Word power is integral to effective and meaningful communication. Students are exposed to various techniques involving etymology, word power building exercises, Synonyms, Antonyms, Usages & Style, Idioms and Phrases, Adages, Proverbs, Professional and Scientific Vocabulary building.

Module 3

Writing Technical articles, proposals, research papers, reports, manuals etc;- Module focuses on scientific aspects involving Experiments, Observations, Comprehension, Analysis , Inferences, Outputs and related presentations as a part of Professional Communication for Readers, Researchers, Fellow Students, Scientific Community and world at large. Technical write-ups involve a lot of team effort, SWOT Analysis, brain storming sessions, proven facts and findings and acknowledgements.

Module 4

Technical Editing and Proof reading – The objective is to finalize the core presentation to be made before the Scientific Group / community, through further refinement involving editing, language precision, reconfirmation of supporting facts and evidences, proper use of graphic aidsfor easy and total comprehension.

References

1. Technical Writing J M Lannon
2. Sentence Skills A workbook for writers John Langon
3. New International Business English Leo Jones, Richard Alexander

SEMESTER II

20-351-0201 ELECTRONICS I - BASIC ELECTRONICS

Course Outcomes

On completion of the course, the student should be able to:

1. define operation of semiconductor devices(Remember level)
2. explain DC and AC models of semiconductor devices(Evaluate level)
3. describe the working of a voltage amplifier(Understand level)
4. apply concepts for the design of Amplifiers (Apply level)
5. design and analyze of electronic oscillators (Analysis level)
6. relate frequency response to understand behaviour of Electronics circuits(Create level)
7. explain the concept of negative feedback in amplifiers (Understand)

Module 1

Diodes and their applications:
Conductors, insulators and semiconductors, Elements of semiconductor physics, p-type and n-type semiconductors, pn junction diode, diode equation, operation and characteristics of diode, breakdown mechanisms in diodes,Introduction to Zener diode, photodiode, solar cell,LED,High frequency switching diodes -tunnel,Gunn, Schottky and varactor diode
Rectification, ripple factor, Rectifiers-Half wave, Full wave and Bridge, Zener shunt regulator, Filters-Different types, Voltage multipliers, clippers, clampers.

Module 2

Transistors -BJTs, pnp and npn transistors, CE, CB, CC configuration, transistor characteristics, small signal BJT model using h-parameters
Unipolar transistors: FET classifications, construction and working of n-channel and p-channel JFET,JFET parameters, MOSFET-enhancement and depletion type operations and their characteristics

Module 3

Transistor biasing: -Need for biasing, faithful amplification, DC load line analysis, operating point, Stability factor (definition only), Biasing Techniques-Base resistor, collector feedback, bias circuit with emitter resistor and voltage divider biasing. Transistor amplifier- Classification of amplifiers, Transistor as an amplifier, CE, CC and CB amplifiers, multistage amplifiers, DC, RC, and transformer coupled amplifiers, Frequency response of RC coupled amplifier
Power amplifiers-Class A, class B, and Class C operations, Push Pull amplifiers

Module 4

Feedback amplifiers: Positive and negative feedback, Advantages of using negative feedback, voltage series feedback, current series feedback, emitter follower

Oscillators: classification, Barkhausen criteria, different types, RC oscillators: RC phase shift oscillator, Wien bridge oscillator,LC oscillators: Hartley, Colpitts and clapp oscillators, crystal oscillator. Multivibrators: Astable, Monostable and Bistable multivibrators

References

1. A textbook of Applied Electronics-R. S. Sedha, S.Chand (2009) (Text)
2. Electronics devices and circuits- Allen Mottershed, Prentice Hall India, (1973) (Text)
3. Electronics Fundamentals: Circuits, Devices & Applications - Thomas L. Floyd, Pearson/Prentice Hall, (2007)
4. Electronics devices and circuit theory- Robert Boylestead and Nasheleski, Prentice Hall, (2004)
5. Integrated Electronics- Millman and Halkias, Tata Mc Grow Hill, (1972)
6. Basic Electronics and Linear circuits- N. N. Bhargava, Tata Mc Grow Hill (1984)

20-351-0202 OPTICS II - PHYSICAL OPTICS

Course Outcomes

On completing this course, the students should be able to :

1. Illustrate the concept of superposition of waves (Apply level)
2. Explain the concept of coherence (Understand level)
3. Classify interference phenomenon based on division of amplitude and division of wavefront (Apply level)
4. Examine Fresnel’s theory to describe diffraction of light (Analyze level)
5. Differentiate between Fresnel and Fraunhofer diffraction (Understand level)
6. Summarize the idea of polarized light, its generation and detection (Understand level)

Module 1

Superposition of two sinusoidal waves, path difference and phase difference, Analytical and graphical methods. Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, optical beats.
Theory of interference and bandwidth, Interference by division of wave front, Young's double slit experiment, Fresnel's bi-prism, Lloyd’s mirrors.

Module 2

Interference by division of amplitude, two beam interference, parallel sided plates, colour of thin films, wedge shaped film, Newton's rings - reflected and transmitted systems, Radius of rings and expression for wavelength, Michelson interferometer, Determination of wavelength separation and standardization of meter. Types of fringes- localized and non-localised fringes in white light

Module 3

Diffraction-Fresnel`s assumptions, Rectilinear propagation of light and Fresnel's theory, Fresnel's zones, theory of zone plate and its comparison with convex lens, Fresnel and Fraunhofer diffractions- Fresnel`s diffraction at straight edge, Cornu's spiral application to diffraction phenomena. Fraunhofer diffraction at single slit, Double slit and multiple slits, missing orders in double slit diffraction pattern, theory of plain transmission grating- oblique and normal incidence, absence spectra, determination of wavelength of light using grating, dispersion and resolving power, Blazed gratings.

Module 4

Polarization , Experimental observation, Polarization by reflection and refraction, Brewster angle, Pile of plates, Biot's polariscope., Malus laws, Double refraction - Optic axis, Uniaxial and biaxial crystals, Geometry of calcite crystals, Nicol prism, Nicol as analyzer and polarizer. Huygen's explanation of double refraction, Quarter wave and Half wave plates, Production and detection of plane, elliptical and circular polarization of light.

Reference

1. Optics, Ajoy Ghatak, 6th Edition,Tata Mc Grow Hill, (2017) (Text)
2. A text book of Optics N Subrahmaniam and Brij Lal, M N Avadhanulu, S Chand and Company , 23rd Edition,(2006)(Text)
3. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013)
4. Optics, Eugune Hecht and A R Ganesan , 4th Edition, Pearson Education (2008)
5. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017)
6. Wave optics and applications - R.S Sirohi ,Orient Longman, (2001)

20-351-0203 MATHEMATICS II

Course outcomes

After completing this course, the student will be able to

1. Understand the concept of gradient, divergence and curl (Understand)
2. Understand elementary transformations of a matrix (Understand)
3. Analyze hyperbolic functions (Analysis)
4. Examine eigen values and eigen vectors of a matrix (Analysis)
5. Understand Greens theorem, Gauss theorem and Stokes theorem (Understand)

Module 1

Vector Calculus Vector differentiation, Gradient, divergence and curl, Solenoidal and irrotational vector point functions.
Vector integration, Line, surface and volume integration, Greens theorem, Gauss theorem and Stokes theorem (statements) Physical interpretations.

Module 2

Matrices inverse of matrices, adjoint matrices (complex conjugate transpose) orthogonal, symmetric, skew symmetric, Hermitian and skew Hermitian matrices, elementary transformations of a matrix.

Module 3

Similarity and unitary transformation of matrices, diagonalisation of matrices, Eigen values and eigen vectors, Cayley-Hamilton Theorem, solution of algebraic equations using matrices consistent and inconsistent equations.

Module 4

Complex numbers Eulers formula, De Moivre's theorem (no proof), nth root of complex number. Trigonometry Expansion of $\sin^n x$, $\cos^n x$ and $\tan^n x$, hyperbolic functions, separation into real and imaginary parts of sine, cosine, tangent, logarithmic and inverse tangent functions, summation of function using C+iS method.

References

1. Mathematical methods of Physics G B Arfken, H J Weber, Academic Press(2001)(Text
2. Differential Calculus Shanti Narayanan, Vishwanathan Publishing Co.(,2000)(Text)
3. Vector Analysis with introduction to Tensor analysis Schaum Series, (1974)
4. Trigonometry S L Loney, S Chand & Co, (2002)
5. Matrices - Shanti Narayanan, S Chand & Co.,(2002)
6. Calculus Vol I & Vol II Manicavachgom Pillai, Vishwanathan Publishing Co.(2000)

20-351-0204 THERMODYNAMICS AND THERMAL PHYSICS

Course Outcomes

After completing this course, the students will be able to

1. Describe thermodynamic systems and processes based on Pressure, Volume, Temperature, and Entropy. (Understand)
2. Employ laws of thermodynamics in relevant thermodynamic processes (Apply)
3. Predict the efficiency of heat engines based on Carnot's cycle (Apply)
4. Discuss Entropy, Thermodynamic functions, and TdS relations (Understand)
5. Apply Maxwell's thermodynamical relations and Gibbs Helmholtz equations (Apply)
6. Classify phase transitions and critical phenomena (Understand)
7. Relate thermal and electrical conductivity to Transport processes (Analyze)

Module 1

Thermodynamic systems, thermodynamic equilibrium- thermodynamic process and cycles, concept of thermodynamic state, extensive and intensive variables; heat and work, internal energy function and the first law of thermodynamics, Equations of states, Laws of thermodynamics, Thermodynamic processes – Indicator diagram (P-V diagram, P-T diagram, T-V diagram, T-S diagram) - Work done in Quasi static process-Work done in Isothermal, Adiabatic, Isochoric, Isobaric processes, First law of thermodynamics-Application of first law to heat capacities-(relation between C_p and C_v) and latent heat– adiabatic and isothermal elasticity of a gas- Theory of specific heat

Module 2

Reversible and irreversible processes, Conditions for reversibility-second law of thermodynamics-heat engine, Carnot's engine and Carnot's cycle, derivation for expression for efficiency, efficiency, Carnot's theorem, Claussius theorem and inequality.
Entropy - Change in entropy in reversible and irreversible processes, principle of increase of entropy-Entropy and available energy- entropy and disorder, Entropy of ideal gas. Temperature - entropy diagram, entropy and second law of thermo dynamics. Nernst Heat Theorem,
Elementary kinetic theory of gases: equilibrium properties — pressure and equation of state, Ideal and real gas, Van der Waal's equation of State.

Module 3

Thermodynamic functions-Enthalpy, Helmhlotz function, Gibbs function-Maxwell's thermodynamic relations-TdS relations-application of Maxwell's thermodynamical relations-variation of intrinsic energy with volume, Joule-Kelvin coefficient, Claussius-Clapeyron equation from Maxwell's thermodynamic relations, Thermodynamic Potential, Gibbs Helmholtz equations

Module 4

Phase transitions and critical phenomena - Phase diagram, first order phase transition. Clausius-Clapeyron 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

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, RevisedFifth edition (2004) (Text).
3. Heat and thermodynamics, Brijlal and Subramanium, S Chand (2008)
4. Introduction to Thermal Physics, D. Schroeder, Pearson (1999).
5. Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanics, S.C. Garg , R.M. Bansal, C.K. Ghosh, TataMcGraw Hill Education Private Limited; 2e edition (2013).
6. Thermal Physics: An Introduction to Thermodynamics, Statistical Mechanics and Kinetic Theory, P.C. Riedi, Macmillan (1976).
7. Heat and Thermodynamics, Zeemansky and R. H. Dittman, Tata McGraw Hill (1997)

20-351-0205 NUCLEAR AND PARTICLE PHYSICS

Course Outcomes

On completion of the course, the students will be able to;

1. recognize constituents of an atom and factors affecting nuclear stability. (Understand)

2. describe nuclear forces using liquid drop and shell model. (Understand)
3. classify nuclear decays and particles involved in it.(Understand)
4. explain various particle detectors and their function (Understand)
5. evaluate radiation hazards and suggest precautions to avoid exposure.(Evaluate)
6. compare different nuclear particles and their properties (Analyze)

Module 1

Atomic nucleus, Nuclear radius – shape – spin – parity – Magnetic and electric Moments, relationship between nuclear radius and mass number, Nuclear forces, nucleons, isotropic spin, isotopes and isobars, isomers, mirror nuclei, stability of nuclei, binding energy, fission and fusion. Nuclear models- semi empirical mass formula, liquid drop model, shell model, magic numbers, Parity of nuclear states, Meson theory of nuclear forces.

Module 2

Nuclear decays: Radio activity, units, radio activity, alpha and beta decay, Gamow's theory, neutrino, Fermi's theory of beta decay, gamma decay (introduction), Radiation hazards. Nuclear fusion and fission. Interaction of radiation with matters (elementary idea), Particle detectors - electroscope, scintillator, bubble chamber, cloud chamber, ionization chamber, GM counter. Cosmic rays- Discovery, latitude, EW, altitude effects, primary and secondary cosmic rays, cosmic ray showers, Bhabha's theory, Pair production and annihilation, Positron and its discovery, discovery of pi and mu mesons and strange particles, van Allen belts, origin of cosmic rays, solar neutrino problem, neutrino oscillation and mass of neutrino.

Module 3

Nuclear reactor- critical condition, design aspects, classification, breeder reactor, effect of nuclear radiation on living systems, Nuclear reactors and environment protection. Particle accelerators -Van de Graff generator, Cyclotron, Synchrotron, Linear accelerator, Colliders.

Module 4

Forces of nature and their unification (introductory ideas), Nuclear reactions, conserved qualities in nuclear reactions, Leptons, Baryons, Mesons and Gauge particles, intrinsic and relative parity of elementary particles. (Elementary ideas of the following) -Gellmann-Nakano-Nishijima relation, fundamental particles and their classifications, Standard model Parity violation and CPT conservation, CP violation and neutral Kaon decay, eightfold way, quark structure.

References
1. Modern Physics- Beiser, Tata Mc Graw Hill, (2002) (Text)
2. Elementary particles and symmetries- I H Ryder, Gordon and Breach, (1975) (Text)
3. Modern Physics- Murugesan, S. Chand and Co, (2008)
4. Elements of Nuclear Physics - W.E. Burcham, Longmans (1981).
5. University Physics with Modern Physics H. D. Young and R. A. Freedman, 11th Edition, (2004).
6. Elements of Nuclear Physics M. L. Pandya & R. P. S. Yadav, 7thEdition, (2002)

20-351-0207 HISTORY OF SCIENCE & TECHNOLOGY

Course Outcomes

After completing the course the students will be able to

1. understand the ancient discoveries in Science (Understand)
2. analyse the emergence of modern Science and the present electronic revolution (Analysis)
3. recognise the Indian contribution during ancient to medieval period (Understand))
4.analyse classical works of certain Mathematicians and Physicists that initiated the development of Optics (Analyse)

Module I

Knowledge in ancient Europe- Plato- Aristotle-Ptolemaic system of Universe-Copernican system-Emergence of true science- Galileo – Kepler- Newton – Faraday and the discovery of electrical machines-The industrial revolution

Module II

Emergence of modern science- Atomic discoveries- Relativity and quantum theory- The nuclear era-The code of life- New materials - The electronic revolution and the IT era

Module III

Astronomy in ancient India, Egypt and other civilizations, some of the astronomical instruments
Indian contribution during ancient to medieval period: sulbasutras, decimal system, number representation (various alpha numeric systems), contributions of Aryabhata, Brahmagupta, Varahamihira, Bhaskara

Contribution by Kerala mathematicians during middle age e.g. Madhava, Neelakanda, Jyeshtadeva. Indian contribution to modern science during the last 200 years-contributions of C V Raman, J C Bose, S N Bose etc

Module IV

Introducing some of the classical works e.g. Aryabhatiyam, Opticks, Galileo's modern science. Principia of Newton. Topics in Philosophy of Science- facts and truth in science- Kanada- Francis Bacon- Thomas Kuhn and Karl Popper- The four percent universe and the current scenario

References:

1. Science in History - J D Bernal, All India Peoples Science Network, Vol 1-4 (1969)
2. Golden Age of Indian Mathematics - S Parameswaran ,1998
3. Mathematics in Ancient and Medieval India - A G Bag , 1979

4. Aryabhatiya of Aryabhata - K V Sharma, INSA, 2009
5. The Sulbasutras - S N Sen and A K Bag, INSA, New Delhi, 1983
6.Lilavati's daughters, Indian National Science Academy, 2007
7. A concise History of Science in India-D N Bose, S N Sen, B V Subbayappa, INSA New Delhi 1989

SEMESTER III

20-351-0301 ELECTRONICS-II ANALOG ELECTRONICS

Course Outcomes

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

1. Explain the working of differential amplifiers and Integrated Circuits *(Understand)*
2. Demonstrate the working of Op-amps and their feedback concepts *(Apply)*
3. Discuss Silicon Controlled rectifiers and unijunction transistors *(Understand)*
4. Differentiate inverting and noninverting amplifiers using op-amps *(Analyze)*
5. Model op-amp analog circuits for various applications *(Analyze)*
6. Operate IC 555 Timer as Astable and Monostable Multivibrator *(Apply)*
7. Interpret the working of GTO, SCS, PUT, and SUS *(Apply)*

Module 1

The differential amplifier- Emitter coupled logic, Common mode and Differential mode gain, CMRR, Single ended AC voltage gain, double ended AC voltage gain Complementary output stage, Improves differential amplifier with constant current source. DC level shifter, Integrated circuits, semiconductor processes, Monolithic ICs, Resistor and capacitor design on ICs.

Module 2

Op-amps: Block diagram representation, Ideal Op-amp characteristics, Equivalent circuit ,Electrical parameters, open loop configurations, Transfer characteristics ,inverting and non-inverting amplifiers, stabilization of gain by negative feedback, voltage follower, current to voltage converter, Inverter and other configurations.

Module 3

Applications of Op-amp-Analog circuits, Adding circuits, Integration and Differentiating circuits, Comparators, detector, Schmitt trigger, Logarithmic amplifier, voltage regulator using Op amps, Analog computations, Basic ideas, active filters op-amp based oscillators: Phase shift and Wein bridge oscillators, introduction to PLL (block diagram),VCO
Functional block of IC 555 Timer, Astable and Monostable Multivibrator.

Module 4

Silicon Controlled Rectifier (SCR) -construction, operation and characteristics, turn on and turn off methods, DIode AC switch(DIAC) and TRIode for Alternating Current(TRIAC), Light Activated Silicon Controlled Rectifier (LASCR), Gate Turn-off Thyristor (GTO), Silicon controlled Switch (SCS), Programmable Unijunction Transistor (PUT), Silicon Unilateral Switch (SUS)
Uni Junction Transistor (UJT)-construction, equivalent circuit, operation and characteristics, application- relaxation oscillator.

References

1. Electronics Fundamental and Applications- J. D. Ryder, Prentice Hall, India, 5 th edition (2009) (Text)

2. Integrated Electronics- Milman&Halkias, Mc Graw Hill- Kogakusha (2003) (Text)
3. Integrated Electronics- K. R. Botkar, Khana Publishers, 9 th Ed (1996)
4. Electronic Principles Malvino, McGraw Hill 4 th Ed (1989)
5. Op- Amps and Linear Integrated circuits- Ramakant A. Gaykward PHI, (1999)
6. Electronic Devices and Circuits - Milman and Halkias,Tata Mc Graw Hill Ed (1991)
7. Power electronics - Soumitra Kumar. Mandal , McGraw Hill Ed(2014)
8. Power Electronics- Daniel W. Hart,McGraw-Hill Ed(2011)

20-351-0302 CLASSICAL MECHANICS

Course Outcomes

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

1. Describe various types of constraints acting on a system. *(Understand)*
2. Describe conservation theorem and symmetry properties. *(Understand)*
3. Apply Lagrange's theorem for simple situations. *(Apply)*
4. Solve the central force problem. *(Apply)*
5. Apply theory of small oscillations to study the normal modes of molecules like CO_2. *(Apply)*
6. Review the equations of motion in Poisson bracket form. *(Understand).*
7. Discuss Hamilton-Jacobi equations. *(Understand).*

Module 1

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 2

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 3

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 4

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)

20-351-0303 OPTICAL INSTRUMENTATION

Course Outcomes

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

1. Demonstrate the use of various interferometers and their applications in different measurements. *(Understand)*
2. Design anti-reflection and high-reflection coatings based on interference technique. *(Apply)*
3. Explain the working principle of grating based monochromators and different grating mounting techniques. *(Understand)*
4. Summarize the adaptive optics technique and its applications. *(Understand)*
5. Outline the working of spectrometers, spectrophotometers, fluorimeters and spectrofluorimeters. *(Understand)*
6. Demonstrate the working of different kinds of lighting sources and their standardization. *(Understand)*
7. Summarize how various optical imaging systems work. *(Understand)*

Module 1

Double beam Interferometry—Interference in a plane parallel plate and in a plate of varying thickness, Fizeau fringes, Mach-Zehnder Interferometer, Sagnac Interferometer, Interferometric measurements of rotation ,Channeled Spectra , Achromatic fringes, Fringes of equal thickness, Fringes of equal inclination, Fringes of equal chromatic order, Phol Interferometer. Speed of light and Michelson Morley experiment. Detection of Gravitational waves using interferometric techniques, Recent Experimentations and Results (LIGO)

Module 2

Multiple beam Interferometry-multiple beam fringes of equal inclination , visibility and Intensity distribution. Fabry Perot Interferometer and Fabry Perot etalon, resolving power and expression for finesse. Nonreflecting films, Highly reflecting films and Interference filters, Broad band reflectors, band pass filters, dichroic beam splitters and cold mirrors.
Wavefront shearing interferometers, Twyman- Green interferometer, Scanning Fabry- Perot Interferometer-central spot scanning, Spherical Fabry-Perot Interferometers, dynamic and static wavelength meters.

Module 3

Theory of concave grating, Mountings for gratings-various mounting techniques, Grating spectrographs, resolution and dispersive power of spectrographs, single beam and double beam monochromators, Spectrometers and flourimeters
Adaptive optics-Wavefront sensor, Guided star systems, MEMS and Deformable mirror and wavefront corrections, actuators, Adaptive optics and vision optics

Module 4

Light sources and Standardization of light sources Incandescent lamps and Fluorescent lamps,- Tungsten and halogen lamps, High pressure and low pressure discharge lamps- Sodium , Hydrogen, Mercury, Metal Halide lamps, Electrode less discharge lamps-magnetic induction lamps, plasma lamps, sulfur lamps, Broad band LED sources, supercontinuum sources.
Imaging systems-Different types of projectors, LCD projectors, Endoscopes, Head up displays, 3D projection systems
Camera, High speed camera, video camera- remote sensing and its applications- Radars and Lidars, Confocal microscopes, Phase contrast microscopes- Introduction to optical imaging.

References

1. Optical interferometry- P Hariharan, Academic press, 3rd Edition (2003) (Text)
2. Optics, Eugene Hecht and A R Ganesan , 4th Edition, Pearson Education (2008) (Text)
3. Basics of Interferometry - P Hariharan, Academic Press(2006)(Text)
4. Optical measurement techniques and applications - P.K Rastogi, Artech House(1997)
5. Principles of Adaptive optics: -R.K Tyson, CRC Press, 3rd Edition (2010)
6. Wave optics and applications - R.S Sirohi ,Orient Longman, (2001)
7. Geometrical and physical optics- R S Longhrust, Orient Longman, 3rd Edition, (1991)
8. Introduction to optics and optical imaging - C.Scott, Wiley-IEEE Press (1998)
9. Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light, Max Born and Emil Wolf, 7th Edition, Cambridge University Press (1999)
10. Light, R W Ditchburn, Dover Publications (2011)
11. Handbook of Optics - Vol I and Vol II - Michael Bass, Mc Graw Hills (2001)
12. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017)
13. Handbook of Applied Photometry- C De Cusatis, AIP Press (1997)
14. Introduction to Solid State Lighting, rtūras Žukauskas, Michael S. Shur, Remis Gaska, Wiley (2002)

20-351-0304 MATHEMATICS II

Course Outcomes

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

1. Understand curvilinear coordinate system *(understand)*
2. apply curvilinear coordinate to physical systems with spherical and cylindrical symmetry *(apply)*
3. Understand and analyse properties of vectors in linear vector space and use it to physical systems, especially in Quantum Mechanics *(analyse)*
4. Understand different methods to solve differential equations and apply it to situations *(Understand &apply)*

5. Understand beta & gamma functions and evaluate integrals of various functions *(Understand and apply)*

Module 1

Curvilinear coordinates: description of curvilinear coordinate system expression for square of distance element, metric-scale factors, differential distance vector, line integral, area element and area vector, volume element and volume integral, expression for the above in rectangular, spherical and cylindrical coordinate system, conversion of unit vectors in spherical and cylindrical coordinated into rectangular coordinates and vice versa.
Expression for gradient, divergence, curl and Laplacian operator in curvilinear coordinate system-corresponding expression in rectangular, spherical and cylindrical coordinate system - physical significance of gradient, divergence and curl, non linear term in Navier-Stoke's equation in hydrodynamics- removal of non linear term

Module 2

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, eigen value and eigen vectors, projection operator, function space, Hilbertspace

Module 3

Partial Differential equations: separation of variables technique, Laplace's equation in rectangular, cylindrical and spherical polar coordinates and their solutions, spherical harmonics. Differential equations: series solution, ordinary and singular points, Frobenius method, Dirac Delta function Green's function technique to solve differential equations

Module 4

Sturm-Liouville Problem, Hermitian differential equations, Beta and Gamma function, orthogonal functions, Legendre, Bessel and Hermite differential equations and their solutions, Legendre, Bessel and Hermite functions and their properties.

References

1. Vector Analysis with an Introduction to Tensor Analysis - Murray R Speigel, Tata McGraw Hill (1975) Schaum series (Text)
2. Classical Mechanics – G Aruldhas, PHI learning, (2014) (Text).
3. Matrices and Tensors for Physicists - A W Joshi, New Age International (1995)
4. Linear Vector Space - Hamos (Text)
5. Mathematics for Physicists and Engineers – G B Arfken, Academic Press (2001), (Text)
6. Mathematics for Physicists - Dennery and Kerzywiki
7. Mathematical Methods for Physicists - G B Arfken, H J Weber Academic Press (2001)
8. A textbook of Mathematical Physics - P K Chakrabarti, S N Kundu Books and Allied Pub, Calcutta (1996)
9. Mathematical Methods in Classical and Quantum Physics - Tulsi Dass, S K Sharma; University Press (1986)
10. Mathematical Physics: Differential equations and Transform Theory - A K Ghatak, I C Goyal, S J Chua; Mc Millan India Ltd.(2002)

11. Mathematical Physics (Parts 1,2 and 3) - J D Anand, P K Mittal, A Wadhwa Har, Anand Publications(2003)

20-351-0305 ATOMIC SPECTROSCOPY

Course Outcomes

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

1. Summarize the shortcomings of classical Physics in explaining microscopic phenomena and the evolution of modern quantum mechanical formulation. *(Understand)*
2. Illustrate the formation of energy levels in and two-electron atoms using the concepts of vector atom model. *(Understand)*
3. Summarize LS interaction and explain how it helps in describing fine structure of spectral lines. *(Apply)*
4. Demonstrate the use of different coupling schemes. *(Apply)*
5. Explain the effects of electric and magnetic fields on atomic energy levels *(Understand)*
6. Evaluate the shift in energy levels due to Zeeman and Stark effects in given elements. *(Apply)*
7. Describe the formation of different types of X-ray spectra and their applications. *(Understand)*

Module 1

Structure of atom: Rutherford model, alpha particle scattering, Bohr atom model, Bohr's interpretation of H atom, Hydrogen spectral series, Ritz combination principle, Combination and intercombination series, Bohr's correspondence principle, Sommerfield relativistic atom model, Wilson Somerfield modification, Vector atom model, Quantum numbers, Larmor theorem. Atomic orbitals and their shapes (no derivation)

Module 2

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, Lande Interval rule.

Coupling schemes: 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 3

Spectra of two electron systems: Alkaline-earth atoms, Mercury spectrum

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.

Module 4

Stark effect : Experiment, Stark effect in Hydrogen, weak field and strong field effect: First order and second order stark effect in Hydrogen (Qualitative ideas only). Hyperfine structure

X-ray spectra: Origin, Continuous and characteristic emission spectra, absorption spectra, explanation, Comparison of optical and X- ray spectra, Mosely's law, importance of Mosely's law

References

1. Atomic spectra- H E White, Tata Mc Graw Hill NY (1983) (Text)
2. Elements of Spectroscopy – Gupta, Kumar and Sharma, Pragathi Prakashan Meerat, 6th edition (2011) (Text)
3. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain, Prentice Hall, 2nd edition (2003)
4. Concepts of Modern Physics, Arthur Beiser and Shobhit Mahajan ,Tata Mc Graw Hill (2009)
5. Spectroscopy, B. P. Straughan, S. Walker Chapman and Hall (1976).
6. Quantum physics of atoms, molecules, solids, nuclei and particles, Robert Eisberg and Robert Resnick , John Wiley, 2nd Edition (2006)

20-351-0306 Lab /Viva
20-351-0307 Seminar

SEMESTER IV

20-351-0401 ELECTRONICS III - DIGITAL CIRCUITS AND MICROPROCESSORS

Course Outcomes

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

1. Compare various positional number systems and binary codes *(Understand)*
2. Apply Boolean algebra in logic circuit design. *(Apply)*
3. Outline the working of various types of registers and counters *(Understand)*
4. Design different types of ADC's and DAC's. *(Apply)*
5. Explain the architecture of 8085 microprocessor *(Understand)*
6. Develop programming skills using 8085 instruction set *(Apply)*.
7. Explain the basic concepts of 16 bit microprocessors. *(Understand)*.

Module 1

Digital fundamentals: the binary number system, octal and other codes, 1's and 2's complements, Binary arithmetic, 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 and Full subtractor, Multiplexer, Encoder and decoder, Demultiplexer Logic families: DCTL, RTL, DTL NAND gate, TTL NAND gate, ECL circuits, PMOS, NMOS and CMOS logics

Module 2

Flip-flop, RS latches, level clocking, D latcher, edge triggered 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 3

Basic D/A converter, variable, resistor networks, binary ladders, A/D converters, counter method, successive approximation, dual slope A/D conversion, A/D accuracy and resolution, VCO, sample and hold circuits, Static RAMs, Dynamic RAMs.

Module 4

Microprocessors 8085: Block diagram, pin out diagram, instruction format, Addressing modes, Instruction types- Data transfer instruction, Arithmetic instructions, Logical instructions, Program control instructions, input output instructions, stack instructions, instruction timing and execution, timing diagrams, Programming Microprocessors. Peripheral operations- Interrupt system, Serial input and Serial output, Programmed I/O ports, Memory interfacing, Direct Memory Access, DMA controller. Introduction to 16 bit microprocessor.

References

1. Digital Computer electronics- Malvino and Brown, Tata McGraw Hill education Pvt. Ltd, 3 rd Ed (1995) (Text)

2. Microprocessor Architecture Programming and applications using 8085 - R. S. Goanker, Prentice Hall India, 5th Ed (2006) (Text)
3. Electronic Devices- Applications and Integrated circuits-Mathur Kulashreshta and Chadha, Umesh publications 5th Ed (1986)
4. Digital principles and applications Malvino&Leach, Tata Mc Grow Hill, 5th Ed (2002)
5. Fundamentals of Micro processers and Microcomputers B. Ram, Bhantat Rai Publishers, 6th Ed (2006)
6. Microprocesser (8085) and its Applications-A. Nagoorkani, RBA Publications (2004)32
7. Digital Logic and Computer Design-M Morris Manno, PHI (1995)
8. Fundamentals of digital circuits- A. Anadan, PHI (2006)
9. Digital circuits and design- S. Salivahanan& S. Arivazhavan, Vikas Pub. 4th Edn (2012)

20-351-0402 STATISTICAL MECHANICS

Course Outcomes

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

1. Discuss the concept of phase space as well as microstates and macrostates. (*Understand*)
2. Explain the statistical origin of thermodynamics and its connection to entropy. (*Understand*)
3. Describe the concept of micorocanonical, canonical, and grand canonical ensembles. (*Understand*)
4. Compute various thermodynamic properties of ideal gas in a canonical ensemble (*Apply*)
5. Discuss Maxwell Boltzmann statistics and velocity distribution based on that. (*Understand*)
6. Compare various theories on Brownian motion (*Understand*)
7. Differentiate Fermi-Dirac and Bose-Einstein distribution (*Understand*)
8. Interpret the thermodynamics of blackbody radiation and Bose-Einstein condensation (*Apply*)

Module 1

Connection between statistics and thermodynamics - macroscopic and microscopic systems- its general descriptions, Quantum states and phase space, density distribution in phase space, Liouville theorem, statistical distribution function, Determination of the number of microstates, statistical origin of thermodynamics, Entropy from the statistical mechanics point, Nernst theorem.

Module 2

Ensemble: microcanonical, canonical and grand canonical ensembles, Canonical Ensemble Theory: distribution function for canonical ensemble, Ideal gases in canonical ensemble, equipartition theorem, Distribution function of grand canonical ensemble.

Module 3

Classical statistics: Distribution laws - Maxwell-Boltzmann distribution. Velocity distribution, relationship between entropy and probability. Partition functions, Partition function of monoatomic gas, Brownian motion, Einstein theory of Brownian motion. Langevin equation for Brownian motion.

Module 4

Quantum Statistics: Bose-Einstein and Fermi-Dirac distributions. Thermodynamic behavior of ideal Bose gas, thermodynamics of black body radiation- Specific heats of solids, Bose-Einstein condensation, Bosons and Fermions, F-D statistics, Thermodynamic behavior of an ideal Fermi gas - Electron gas in metals.

References

1. Statistical Mechanics - K Huang, John Wiley & sons, 2nd edition (2008)
2. Modern Thermo Dynamics-D. Kondepadi. Ilya Prigogene, John Wiley sons (1998)
3. Statistical Mechanics Kamal Singh, S. Chand and Co, New Delhi, 1st edition (1988)
4. Statistical Mechanics R. K. Pathria, Butternorth-Heinemann, (1972)
5. Modern Physics- Beiser, Tata Mc Graw Hill, (2002)
6. Statistical Mechanics, A survival Guide- A. M. Glazer and J. S. Wask, Oxford University Press (2001)
7. Introductory Stastistical physics-Roger Bowle, Academic press
8. Statistical Physics, Berkeley Physics Course Vol 5, F Reif, Tata McGraw Hill, 2011
9. Statistical Mechanics, R. K. Pathria, 2nd edition, Elsevier (2002)
10. Landau and Lifshitz , Statistical Physics

20-351-0403 QUANTUM MECHANICS I

Course Outcomes

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

1. Describe the inadequacies of classical mechanics and the origin of quantum theory. *(Understand)*
2. Summarize the concept of wave packet. *(Understand)*
3. Explain the properties of wave function. *(Understand)*
4. Review time independent and time dependent Schrodinger equations. *(Understand)*
5. Discuss the postulates of quantum mechanics. *(Understand)*
6. Solve particle in a box, potential barrier, potential well and harmonic oscillator problems using Schrodinger equation. *(Apply).*
7. Apply Schrodinger equation for spherically symmetric potentials. *(Apply).*

Module 1

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 uncertainty principle, uncertainty relations, motion of wave packets, propagation of wave packet without distortion, group and phase velocities.

Module 2

Schrodinger 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 super position principle.

Module 3

Postulates of Wave Mechanics, Dynamical variables as operators, Linear operators, Commutator brackets, Eigen functions and Eigen values, Hermitian operators and their properties, Orthogonality conditions, Schimidt's orthogonalization procedure, Physical significance of Eigen functions and Eigen values, Degeneracy, Simultaneous measurability of observables, general uncertainty relations.

Module 4

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. Quantum mechanics- Mathews and Venketesan, Tata McGraw Hill (2006)
6. Quantum Mechanics-Thankappan V K, New Age International, 2nd edition (2003)
7. Introduction to Quantum Mechanics – David J Griffiths, Pearson, 2nd edn

20-351-0404 ELECTROMAGNETIC THEORY AND RELATIVISTIC PHENOMENA

Course Outcomes

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

1. Explain the concepts of electrostatics, electric field, electric potential and energy density. *(Understand)*
2. Apply the concepts of electrostatics to solve the problems relating to electric Field and electric potential. *(Apply)*
3. Apply the concepts of magneto statics to solve the problems relating to magnetic field and Magnetic potential. *(Apply)*
4. Solve problems related to electromagnetic boundary conditions . *(Apply)*
5. Understand the concepts related to Faraday‘s law and Maxwell‘s equations. *(Understand)*
6. Analyse the propagation, reflection and transmission of plane waves. *(Analyse)*
7. Explain magnetism as a relativistic phenomenon of electricity . *(Understand)*

Module 1

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, induces 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 2

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 3

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 4

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, Pearson Education India Learning Private Limited, 4th edition (2015) (Text)
2. 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 Graw Hill (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. Electromagnetic waves and radiating systems- Jordan E C and K G Balmian, Prentice Hall India Learning Private Limited, 2nd edition (1998)
10. Introduction to special theory of relativity, R Resnick, Wiley India edition (2010)

20-351-0405 MATHEMATICS IV

Course Outcomes

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

1. Illustrate the properties of tensors and their operations *(Understand)*
2. Examine properties of material like polarisability, elasticity etc *(Analyse)*
3. Explain integral transforms *(Understand)*

4. Apply Fourier Transform to find solutions to certain differential equations *(Apply)*
5. Discuss various functions of complex variables *(Understand)*
6. Apply contour integration to evaluate integrals *(Apply)*
7. Discuss symmetries and basic group theory *(Understand)*

Module 1

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, stress, strain and Hooke's law, moduli of elasticity, piezo electricity and dielectric susceptibility

Module 2

Fourier series, Laplace Transform, Laplace Transform of some simple functions, solving Differential equations using Laplace Transform. Fourier Transform, Properties of FT, Convolution Theorem, Solving Differential equations using FT.

Module 3

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 4

Group Theory: Definition, Examples, properties of a group, Sub Group, Group multiplication table, Cyclic Group, Permutation group, Isomorphism and homomorphism of Groups, Cayley's theorem, Conjugate elements and classes, Representation of group, Reducible and Irreducible representations, Character table, Group of symmetry of an equilateral triangle and a square.

References

1. Mathematics for Physicists and Engineers – G B Arfken, Academic Press (2001), (Text)
2. Chemical Applications of Group Theory- F A Cotton, Wiley Eastern (1971)(Text for module III)
3. Mathematical methods in Classical and Quantum Physics- T Dass & S K Sharma
4. Complex Variables- Schaum Series
5. Elements of Group Theory for Physicists- A W Joshi, Wiley Eastern Ltd, 3rd Edition (1988)
6. Introductory methods of Numerical Analysis- C S Sastry Prentice Hall India (2001) (Text)
7. Numerical Methods- Balagurusamy, Tata McGraw Hill (2001)
8. Elements of group theory for Physicists, A W Joshi, Wiley Eastern Ltd, 3rd edition, (1988)
9. Churchill-Complex variable theory

20-351-0406 LAB/VIVA

20-351-0407 WORKSHOP
(Engineering drawing Practice to be given)

20-351-0408 SEMINAR/VIVA

SEMESTER V

20-351-0501 OPTICS IV APPLIED OPTICS

Course Outcomes

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

1. Understand concept of radiometry and photometry *(Understand)*
2. Explain diffraction phenomenon using Fresnel-Kirchoff integral *(Understand)*
3. Analyze diffraction patterns *(Analyze)*
4. Understand devices that use polarization of light *(Understand)*
5. Apply matrix optics for studying polarization *(Application)*
6. Understand Poincare sphere *(Understand)*

Module 1

Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCS chromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity , colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency ,colour vision model

Module 2

Diffraction – Fraunhofer and Fresnel diffractions, Fresnel-Kirchoff integral, Fourier transform in Fraunhofer diffraction, diffraction by a single slit, diffraction by a rectangular aperture, two slit Fraunhoffer diffraction pattern, N-slit Fraunhoffer diffraction pattern, fourier transforming property of lens, spatial frequency filtering

Module 3

Birefringence-Birefringent crystals, polarisers, polarization beam splitters, Wave plates (half-wave, Full-wave and quarter-wave), Compensators and Variable retarders, Circular polarizers Optical activity - Dextro and levorotatory substances, optical activity in liquids, Half-shade plate, Laurrents half-shade polarimeter
Optical anisotropy-Index ellipsoid, Stress birefringence – Photoelasticity

Module 4

Analysis of Polarization- Mathematical description of polarization, states of polarization, polarization ellipse, special forms, Elliptical parameters, Stokes polarization parameters, Stokes vectors, Stokes parameters for polarized and unpolarized light, Stokes Intensity formula Jones and Mueller matrix calculus- Matrices for polarizer, retarder, and rotator in both representations, Neutral density filter, Mueller matrix for Depolarizer
Poincare sphere, Representation of polarization states

References

1. Handbook of Applied Photometry - C De Cusatis, AIP. (1997)
2. Introduction to Soild State Lighting - Zukauskas, Shur, Caska, Wiley (2001)
3. Optics - Eugene Hecht (3rd Edition), Addison Weseli Long inc (1998)
4. Polarized light – Edward Collet, Marcel Decker (1992)

5. Introduction to Optoelectronics- Wilson and Hawkes, PHI, (1996)
6. Wave optics and Applications - R. S. Sirohi, Orient Longmann (2001)
7. Optical Electronics - Thyagarajan and Ghatak, Cambridge University Press (1997)
8. Polarization of light - S. Huard, John Wileyand Sons (1997)
9. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2003)
10. Optics- Ajoy Ghatak, McGraw Hill (2010)

20-351-0502 ELECTRONICS IV - ELECTRONIC INSTRUMENTATION

Course Outcomes

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

1. Understand various types of transducers, where the physical quantities such as temperature, pressure, are sensed and converted into equivalent electrical signals. *(Understand)*
2. Understand how these electrical signals such as current, voltage, or other electrical parameter are measured using conventional deflection-type measuring instruments and modern digital meters. *(Understand)*
3. Analyze how these signals can be processed in time and frequency domains *(Understand)*
4. Understand how the measured quantities are indicated and recorded, using oscilloscope and recorder *(Understand)*

Module 1

Definition of transducers- classification of transducers - Passive transducers: principle of operation construction details- characteristics and applications of passive electrical transducers-strain gauge parameters and types, temperature transducers –resistance thermometers, thermistors, inductive transducers -variable reluctance transducers- LVDT, capacitive transducers- variable air gap type, variable area type, variable permittivity type, Active transducers: Thermo electric transducers, Piezo electric transducers. Photoelectric transducers Data converters, DAC and ADC transfer characteristics, conversion techniques, performance parameters, Voltage to frequency converters. serial interfacing standards RS232C,RS422A, IEEE 488 (GPIB). Introduction to microcontrollers, Basic ideas of 8051 micro controller, architecture

Module 2

DC deflection instruments: D'Arsonval movement in DC meters- suspension mechanisms, Principle of operation of galvanometers -PMMC-as voltmeter, ammeter & ohmmeters,
AC Deflection measurements: electro dynamometer instruments-electro thermic type instruments - hotwire ammeters & thermo couple ammeters- rectifier type instruments-full wave & half wave, digital instruments-resolution and sensitivity in digital meters –digital voltmeter (DVM) - ramp & integrating type, Digital Multimeters (DMM), comparison measurements —Basic AC and DC potentiometers- self balancing potentiometers

Module 3

Tuned amplifiers Chopper stabilized amplifiers, Harmonic distortion in amplifiers. Signal analysers - Wave analyser —heterodyne & frequency selective, voltage and gain output measurements. Spectrum analyser, Lock in Amplifiers, BOXCAR averager

Module 4

Cathode Ray Oscilloscope: — Basic Principle — CRT features — Block diagram of Conventional CRO and, general CRO types-dual beam &dual trace, front panel controls of CRO-triggered modes & time base generation circuits, General performance parameters bandwidth, rise time and sensitivity, Special types of CRO — Sampling oscilloscope — Storage oscilloscope-Digital storage Oscilloscope (DSO), CRO measurements-lissajous figures measurement of phase difference and frequency, Graphic recorders —strip chart recorders & X-Y recorders.

References

1. 1. Electrical and electronic instruments, G. K. Banerjee, PHI learning Pvt. Ltd. (2012) (Text)
2. Elements of electronic instrumentation and measurement - J J Car, Prentice HallIndia (1986)
3. Electronic Instrumentation- H. S. Kalsi, Tata Mc Graw Hill (2006)
4. Industrial and Solid State Electronics: Devices and Systems - T. J. Maloney, PrenticeHall India (1986)
5. A course in electrical and electronic measurement and instrumentation A. K. Sawhney, DanapathRai and Co (2005)
6. Transducers and Instrumentation P. V. S. Murthy, Prentice Hall India (2003)

20-351-0503 QUANTUM MECHANICS II

Course Outcomes

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

1. Describe the representations in continuous bases. *(Understand)*
2. Use the operator method for solving the harmonic oscillator problem. *(Apply)*
3. Predict the eigenfunctions and eigenvalues of of J_z, J^2, L_z and L^2 operators *(Apply)*
4. Explain Pauli Spin matrices and spin angular momentum. *(Understand)*
5. Demonstrate time independent and time dependent approximation methods in quantum mechanics. *(Apply)*
6. Illustrate transition rates in absorption/emission processes. *(Apply).*
7. Discuss Scattering theory. *(Understand).*
8. Apply scattering theory to study scattering from hard sphere, square well and Coulomb potentials. *(Apply)*

Module 1

Representation in continuous bases: Position and Momentum representations in quantum mechanics, connecting position and momentum representations, parity operator, Matrix and wave mechanics. Solution of linear harmonic oscillator: Operator method, coherent states, matrix representation of creation, annihilation, number, position and momentum operators of harmonic oscillator.

Module 2

Orbital angular momentum, General formalism of angular momentum, eigenfunctions and eigenvalues of J_z and J^2, matrix representation of angular momentum, geometrical representation of angular momentum, eigenfunctions and eigenvalues of L_z and L^2. Spin angular momentum: general theory of spin, Pauli spin matrices.

Module 3

Time independent perturbation-first order and second order correction, the stark effect, Degenerate perturbation theory; Variational method, hydrogen and helium atoms; WKB approximation, tunnelling through potential barrier.
Pictures of quantum mechanics, Schrödinger picture, Heisenberg picture and interaction picture.
Time dependent perturbation theory: first order approximation, transition probability for constant and harmonic perturbations, Fermi-Golden rule.

Module 4

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, square well and coulomb scattering, scattering of identical particles.

References

1. Quantum Mechanics: Concepts and Applications, 2nd Edition, Nouredine Zettili, John Wiley & Sons, 2009 (Text)
2. Quantum Mechanics G Aruldhas, Prentice Hall India,(2004)
3. Quantum mechanics Mathews and Venketesan ,Tata McGraw Hill (2006)
4. Modern Quantum Mechanics- J J Sakurai, Pearson Education ,Revised Ed (2003)
5. Quantum Mechanics-Thankappan VK , New Age International (P)Ltd, 2nd edition (2003)

20-351-0504 MATERIAL SCIENCE

Course Outcomes

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

1. Describe structural elements such as crystal planes and directions using standard notations. *(Understand)*
2. Explain the concepts of reciprocal lattice and Brillouin zones. *(Understand)*
3. Apply the theory of lattice vibrations (phonons) to determine thermal properties of solids. *(Apply)*
4. Discuss the role of quantisation in describing low temperature lattice heat capacities using Einstein and Debye models. *(Understand)*
5. Explain the concept of density of states and occupation to determine macroscopic properties of solids. *(Understand)*
6. Formulate the problem of electrons in a periodic potential. *(Analyze)*
7. Analyse electron dynamics in semiconductors and the effect of doping on the electronic properties of semiconductors. *(Analyze)*
8. Outline the theory of dielectric and magnetic properties of materials. *(Understand)*

Module 1

Crystal symmetry and crystal systems: translational vectors and lattices, unit ISPl, 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 and hydrogen bonds.

Module 2

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.

Module 3

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

Module 4

Dielectric properties of solids: polarisability, local electric field of an atom, ferroelectric crystals, Clausius Mosotti 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, hysterisis, BH curve, adiabatic demagnetization.

References

1. Solid State Physics – C Kittel, 7th 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)

20-351-0505 MOLECULAR SPECTROSCOPY

Course Outcomes

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

1. Discuss the microwave spectra of rigid and non-rigid molecule – *(Understand)*
2. Explain the theory of rotation-vibration spectra of diatomic molecule – *(Understand)*
3. Describe the various modes of vibration of linear and non linear triatomic molecule- *(Understand)*
4. Apply Raman and IR spectroscopy to determine the structure of the molecule – *(Apply)*
5. discuss the electronic spectra of diatomic molecule and explain the intensities of spectral line in vibrational electronic spectra *(Understand)*
6. illustrate the various spectroscopic experimental technique
7. Compare NMR and ESR spectroscopy and their applications *(Analyse)*

Module 1

Crystal symmetry Microwave spectra of molecules: Rotational energy levels of rigid and non rigid diatomic molecules, Rotational term values, Pure rotational spectra of diatomic molecules, Effect of isotopic substitution on spectra.
Polyatomic molecules: Linear and symmetric top, Microwave spectrometer, Evaluation of molecular constants, Diatomic vibrating rotator, Vibrational term values, Evaluation of vibrational constants of diatomic molecules.
IR spectroscopy : Pure vibration spectrum of diatomic molecules, SHO and anharmonic oscillator, Interaction of rotation and vibration, Breakdown of Born- Oppenheimer approximation.

Module 2

Vibration of polyatomic molecules: Modes of vibration of linear tri atomic and non-linear tri atomic molecules with special reference to CO_2 and H_2O. Linear and symmetric top—Analysis by IR spectroscopy. Experimental techniques of IR spectroscopy.
Group theoretical applications in molecular spectroscopy with special reference to molecules like water
Raman spectroscopy: Classical and quantum theory of Raman effect, Stokes and anti-stokes Raman lines, Pure rotational Raman spectra, Linear , symmetric top and spherical topmolecules, Vibrational Raman Spectra, Complemetary nature of IR and Raman Spectra, Structure determination from Raman and IR spectra, Experimental techniques and instrumentation.

Module 3

Electronic spectroscopy: Electronic spectra of diatomic molecules, Vibrational coarse structure, progressions and sequences, Deslander's table, isotope effect, Frank-Condon principle, Intensity distribution in absorption and emission spectra, Dissociation and predissociation, Evaluation of dissociation energy, Rotational fine structure of electronic spectra—P, Q, R branches, Band head formation, Band shading, Fortrat parabola, Basic ideas of experimental techniques.

Module 4

Spin resonance spectroscopy: Spin and applied field- Nuclear Magnetic Resonance – Theory, Experimental techniques , Relaxation, Chemical shift, Medical applications. ESR: Theory and experimental techniques, g – factor, Hyperfine structure. Mossbauer's spectroscopy: Mossbauer's effect, theory and experimental techniques, Isomer shift.

References

1. Fundamental of Molecular Spectroscopy- C N Banwell and Elaine M McCash, Tata Mc Graw Hill, 4 th edition 2016 (Text)
2. Molecular structure and spectroscopy- G. Aruldhas, Prentice Hall of India Learning Pvt. Ltd. (2007) (Text).
3. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain, Prentice Hall, 2nd edition (2003)
4. Quantum physics of atoms, molecules, solids, nuclei and particles, Robert Eisberg and Robert Resnick , John Wiley, 2nd Edition (2006)
5. Molecular Spectra and Molecular Structure: Spectra of diatomic molecules- G Herzberg, Krieger Pub Co; 2nd edition (1989)
6. Chemical Applications of Group Theory- F A Cotton, 3rd Edition, Wiley (2008)

20-351-0506 LAB/ VIVA

20-351-0507 SEMINAR

SEMESTER VI

20-351-0601 PHOTONICS I - OPTOELECTRONICS

Course Outcomes

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

1. Develop the concept of optical transitions in semiconductor materials *(Understand)*
2. Describe basic laws and phenomena that define behaviour of optoelectronic systems. *(Understand)*
3. Explain the functionalities of LEDs and Laser diodes *(Understand)*
4. Compare and evaluate different device designs of LEDs and Laser diodes *(Analyse)*
5. Compare the operation principles, characteristics, design architectures and trade-offs of optical detectors and modulators. *(Analyse)*
6. Utilize the knowledge about photodiodes to design a simple photodetector circuit *(Apply)*
7. Classify operational modes and luminescence mechanisms involved in various display devices. *(Understand)*

Module 1

Optical properties of semiconductors- Radiative and non-radiative recombination, band to band recombination, exciton absorption, donor- acceptor and impurity band absorption, long wavelength absorption, Relation between absorption and emission –stokes shift in optical transitions, near band gap transitions, Deep level transitions, Auger recombination

Module 2

Junction Theory-PN junction- current density across junctions, injection efficiency, Quasi-fermi level and high level injection, graded junctions- heterojunction, double heterojunction quantum well and quantum dots, superlattices Basics of all solid state lamps- LED materials and device configurations, efficiency, high brightness LEDs , light extraction from LEDs, DBR, LED structures- SH, DH, SQW,MQW- device performance characteristics White solid state lamps-generation of white light and applications

Module 3

Opto-electronic detectors-Thermal detectors, Photoconductive detectors - junction photodiodes, P-I-N photodetector- quantum efficiency and frequency response, Silicon photodiodes- performance characteristics APD- design issues and band width, Phototransistors, Modulated barrier photodiodes, Schottky barrier PD, Metal Semiconductor photodetectors, MSM PD, Detectors for long wavelength operation, Microcavity PD Solar cells- I-V characteristics and spectral response, Materials and design considerations of solar cells

Module 4

Display devices- PL, EL, CL displays, displays based on LED , Plasma panel and LCD Optoelectronics modulation –Analog and Digital modulation, Optical heterodyning and electro-optic measurements, fibre coupling, EO,AO, and MO based switching devices and modulators, SEED

References

1. Semiconductor optoelectronic devices- Pallab Bhattachraya, PHI, ISBN-978-81203-2047-5 (2009) (Text)
2. Semiconductor optoelectronics- Jasprit singh, Tata Mc Graw Hill (1995) (Text)
3. Semiconductor physics and optoelectronics- V Rajendren, J. Hemaletha, M Stalin Maccolin, Vikas Publishers Delhi(2004), ISBN,81-259-1448-X
4. An introduction to Optoelectronics- Wilson and Hawkes , PHI, (1996) 5. Light Emitting Diodes- E Fred Scheubert, Cambridge University Press , (2003)
5. Solid State Lighting- Zukaszukasu, John Wiley Sons , NY (2002)43
6. Optoelectronic devices and systems – S C Gupta , PHI, (2005)
7. Solid state Electronic devices- Ben G Streetmann and Sanjay Banerjee,PHI(2003)5 th Edition, ISBN-81-203-1840-4
8. Introduction to Semiconductor Materials and Devices- M S Thyagi, John Wiley Sons, NY, (2003)
9. Physics of semiconductor devices- S M Sze John Wiley Eastern 2 nd Edition, (2002) ISBN-9971-51-266-1

20-351-0602 PHOTONICS II - FIBRE OPTICS

Course Outcomes

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

1. Explain the theory of propagation of light in planar and cylindrical waveguides *(Understand)*
2. Describe the formation of modes in a planar optical waveguide *(Understand)*
3. Classify optical fibers based on their refractive index profiles *(Understand)*
4. Examine the loss mechanisms in optical fibers and to compute various losses *(Apply)*
5. Compare different types of pulse broadening mechanisms in optical fibers *(Understand)*
6. Distinguish different techniques to fabricate various types of optical fibers and connectors *(Understand)*
7. Analyze the functioning of optical fiber sensors *(Analyze)*

Module 1

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 2

Transmission characteristics of optical fibre, attenuation, absorption and scattering losses, nonlinear 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 - Self phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.

Module 3

Optical fibre measurements – Attenuation, loss 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, Cable, Fiber joints, fiber polishing, Industrial, medical and technological applications of optical fibre.

Module 4

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 and fibre gyro, temperature, pressure, force and chemical sensors.

References

1. Optical Fibre communication - J. M. Senior. Prentice Hall India (1994) (Text)
2. Optical Fibre communication systems - J. Gowar, Prentice Hall India (1995)
3. Fibre optic communication - J. Palais, Prentice Hall India (1988)
4. Fundamentals of Fibre Optic Telecommunication -B. P. Pal., Wiley Eastern (1994)
5. Integrated Optics - R. G. Huspcrger. Springer Verlag, (1998)
6. Fundamentals of Fibre Optics-B. P. Pal, Wiley Eastern, (1994)
7. Understanding Fiber optics- J. Hecht, Pearson Edu. Inc (2006)
8. An introduction to Fiber Optics, Ghatak and Thyagarajan, Cambridge University Press 1998.
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)

20-351-0603 PHOTONICS III - LASER PHYSICS

Course Outcomes

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

1. Summarize radiative and non-radiative transitions *(Understand)*
2. Explain various emission broadening mechanisms *(Understand)*
3. Describe Einstein's treatment of absorption and emission of radiation *(Understand)*
4. Discuss the conditions required for laser action *(Understand)*
5. Solve the rate equations for two-, three- and four-level laser systems *(Apply)*
6. Predict the stability of laser cavity *(Apply)*
7. Review the safety requirements of lasers *(Understand)*

Module 1

Radiative transitions and emission linewidths Radiative decay of excited states, Spontaneous emission, decay rate, transition probability, spectral linewidths, spectral line shapes and various line broadening mechanisms, homogeneous and inhomogeneous broadening.

Radiation and thermal equilibrium: Radiation in a cavity, Modes of oscillation, Rayleigh- Jeans and Planck's radiation formula, field quantization, relationship between cavity radiation and blackbody radiation, Absorption and Stimulated emission, Einstein's A and B coefficients.

Module 2

Conditions for producing a Laser : Absorption and gain of homogeneously broadened radiative transition, gain coefficient and stimulated emission cross section for homogeneous and inhomogeneous broadening.
Necessary and sufficient conditions for laser action: Population inversion (necessary condition), saturation intensity (sufficient condition), Development and growth of a laser beam, shape or geometry of amplifying medium, exponential growth factor (gain), threshold requirements for a laser with and without cavity.
Laser Oscillation above threshold: Laser gain saturation, Laser beam growth beyond the saturation intensity, Optimization of laser output power, laser output fluctuations- laser spiking, relaxation oscillations. Laser amplifiers (Elementary ideas only).

Module 3

Requirements for obtaining population inversions: Inversions and two level systems, rate equations for three and four level systems, pumping mechanisms.
Laser cavity modes: Longitudinal laser cavity modes, FP resonator, transverse laser cavity modes, Properties of laser modes, spectral and spatial hole burning, properties of Gaussian beams
Stable laser resonators: Stable curved mirror cavities, ABCD Matrices, cavity stability criteria, unstable and ring resonators.

Module 4

Q-switching: Theory, giant pulses, methods of producing Q-switching within a laser cavity, gain switching.
Mode locking : Theory, picosecond optical pulses, techniques for producing mode-locking,
Pulse shortening techniques: Generation of ultrashort optical pulses, Self phase modulation, pulse compression (shortening) with gratings or prisms, femtosecond optical pulses and techniques to characterize femtosecond pulses.
Properties of laser beams and techniques to characterize laser beam, Semi classical theory of lasers, polarization in the medium, first order theory

References

1. Laser fundamentals- W. T .Silfvast, 2 nd edition, Cambridge University Press (2008) (Text).
2. Lasers: Fundamentals and Applications, K. Thyagarajan and Ajoy Ghatak, Springer, 2nd edition (2011)
3. Principles of Lasers, Orazio Svelto and David C. Hanna, Springer, Fifth Edition (2010)
4. Lasers, A. E. Siegman, Univ Science Books; Revised ed. edition (1986)
5. Laser Physics, Peter W. Milonni, Joseph H. Eberly , Wiley (2010)

20-351-0604 MATHEMATICAL MODELLING AND COMPUTATIONAL TECHNIQUES

Course Outcomes

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

1. Solve transcendental and algebraic equations using numerical methods *(Apply)*
2. Apply different numerical models for performing differentiation and integration *(Apply)*
3. Apply different numerical techniques to perform line and curve fitting. *(Apply)*
4. Solve ordinary differential equations using numerical methods *(Apply)*
5. Solve partial differential equations using numerical techniques. *(Apply)*
6. Explain the basics of Python computer language. *(Understand)*

Module 1

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

Module 2

Numerical differentiation: first and second order derivatives. Numerical Integration: trapezoidal, Simpson's and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler's method and Runge-Kutta methods.

Module 3

Solutions of partial differential equations - finite difference method. Finite element method: application to one-dimensional problem, Meshless method: application of meshless methods to solve partial differential equations, Randomisation, Monte Carlo methods. FDTD method for solving one-dimensional problems.

Module 4

Introduction to Python 3.0 Programming - Data Types, Variables, Input-Output operations – Conditional Execution- Loops and List processing - Functions- Tuples- Dictionaries – Modules and Packages – Object oriented Programming – Classes, Methods. Data frames and Data analysis using Pandas, Introduction to NumPy, creating arrays, Attributes and Functions, Slicing, Data visualization using Matplotlib, Usage of Jupyter Notebooks.

References:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India, 5th Ed., 2012 (Text)
2. An introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text)
3. Numerical Methods in Science and Engineering, M. K. Venkataraman, National Publishing Co. Madras, 5th Ed., 1999.
4. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House, 1995.
5. Hua Li, Shantanu S. Mulay, Meshless Methods and their Numerical Properties, CRC Press, Singapore, 2013.
6. Mathematical Modeling – J. N. Kapur, New Age publishers, 2008.
7. Learning Python, Mark Lutz, O'Reilly Publications, 5th Ed., 2013.
8. Python for Data Analysis, Wes McKinney, 2nd Ed., O'Reilly Media, Inc., 2017.
9. Python Data Science Handbook, Jake VanderPlas, 1st Ed., O'Reilly Media, Inc., 2016.
10. SciPy and NumPy: An Overview for Developers, Eli Bressert, O'Reilly Media, Inc., 2nd Ed., 2013.

20-351-0605 PROJECT/VIVA

20-351-0606 COMPUTER LAB

SEMESTER VII

20-351-0701 ADVANCED SOLID STATE THEORY

Course Outcomes

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

1. Recall the concept of band theory and Bloch function *(Remembering)*.
2. Apply free electron model to describe heat capacity, conductivity and resistivity *(Apply)*.
3. Understand carrier transport in semiconductors *(Understand)*.
4. Make use of quantum theory to unravel the origin of different types of magnetism *(Apply)*.
5. Explain electron-electron interaction and electron-phonon interaction *(Understanding)*.
6. Develop the theoretical description of superconductivity *(Apply)*.
7. Experiment with optical processes in semiconductors *(Apply)*.
8. Analyse the electronic properties of low dimensional systems such as quantum wires and quantum dots *(Analyse)*.

Module 1

Free electron Fermi Gas: energy levels in one dimension, effect of temperature on Fermi-Dirac distribution, free electron gas in three dimensions, heat capacity of electron gas, experimental heat capacity of metals, electrical conductivity and Ohm's law, experimental electrical resistivity of metals, motion in magnetic fields, Hall effect, thermal conductivity of metals, Wiedemann-Franz law.

Band gap in semiconductor crystals, equations of motion of an electron in an energy band, holes, effective mass, physical interpretation of effective mass, effective masses in semiconductors, intrinsic carrier concentration, impurity conductivity.

Module 2

Magnetism (Quantum View): para, dia, ferro and ferri magnetism, Weiss molecular field, Neel model of anti-ferromagnetism, spin wave.

Dielectric function of the electron gas, dispersion relation for electromagnetic waves, transverse optical modes in a plasma, longitudinal plasma oscillations, Plasmons, electrostatic screening, Mott metal-insulator transition, screening and phonons in metals, Polaritons, Electron-electron interaction, Electron-phonon interaction: Polarons.

Module 3

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, BCS ground state, flux quantization in a superconducting ring, single particle tunneling, Josephson effects, SQUID, high temperature superconductors, applications.

Module 4

Optical processes in semiconductors: electron-hole pair formation and recombination, absorption in semi-conductors, donor and acceptor impurity bands, oscillator strength of band-to-band transition, Franz-Keldysh and Stark effects, luminescence emission from semiconductors.

Quantum confined systems: quantum confinements and its consequences in idealized quantum wells, quantum wires and cubic quantum dots. Artificial atoms, electronic structures from bulk to quantum dots. Electron states in direct gap semiconductors, electronic states in indirect gap semiconductors, hole states.

References

1. Introduction to Solid State Physics - C. Kittel, 7th Ed., John Wiley (2004) (Text)
2. Solid state Physics - J. R. Hook and H. E. Hall, 2nd Ed., John Wiley and Sons (1993)(Text)
3. Semiconductor Optoelectronics - Pallab Bhatacharya, 2nd Ed., Prentice Hall (2002) (Text for module IV)
4. Nanostructures: Theory and Modelling - C. Delerue and M. Lannoo, Springer Verlag (2004) (Text for module IV)
5. Solid State Physics - A. J. Dekker, MacMillan India Ltd. (2005)
6. Solid State Physics - M. A. Wahab, 2nd Ed., Narosa Publishing House Pvt. Ltd. (2005).
7. Solid State Physics - N. W. Ashcroft and N. David Mermin, Harcourt (1976)

20-351-0702 LASER SYSTEMS

Course Outcomes

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

1. Explain the basic characteristics of a laser beam and their measurements *(Understand)*
2. Illustrate the safety hazards and safety measures related to lasers *(Understand)*
3. Classify lasers based on the type of gain media *(Analyze)*
4. Demonstrate the working of solid state and gas lasers. *(Apply)*
5. Identify the characteristics of materials that can be used as laser gain media *(Understand)*
6. Describe the generation and amplification of ultrafast laser pulses *(Understand)*
7. Discuss different methods used for spectral and temporal characterization of ultrafast optical pulses *(Understand)*
8. Explain the basic principle behind generation of attosecond pulses *(Understand)*

Module 1

Characteristics of laser beams: Monochromaticity, Spatial & temporal coherence, temporal coherence & monochromaticity relation, connection between spatial coherence and directionality, brightness, Peak Power, Average Power, Duty Cycle in Pulsed Lasers.
Measurement of laser characteristics: energy, beam diameter, divergence, pulse width

Laser hazards and safety measures: Types of hazards, hazards to eyes and skin, Maximum Permissible Exposure (MPE), Classification of lasers from the point of view of hazards, safety measures, laser safety measures.

Module 2

Gas lasers: General principle of population inversion in gas laser excitation and depopulation mechanisms-pulsed and continuous wave lasers-collision lasers. Helium Neon gas laser-energy levels-

energy transfer-excitation methods- fabrication details-operating characteristics. He-Cd lasers-laser structure-excitation mechanism.
Molecular gas lasers: Discharge in molecular CO2 - inversion mechanisms- CO2 laser modes-CW and pulsed CO2 lasers-power supply of CO2 lasers-laser amplifier-TEA CO2 lasers-Nitrogen laser-pumping method-emission characteristics-pulsed N2 laser design.
Ion laser: Argon ion energy levels - excitation mechanisms-fabrication of argon ion lasers-uv emission-Excimer and metal vapour rare gas dimers-electronic structure-rare gas excimer-energy level diagram - excimer decay mechanism

Module 3

Solid state lasers: properties of solid state laser materials fluorescence emission in solids - Ruby Nd. YAG, Nd: Glass lasers - laser energy levels pumping sources and cavity configurations - power supply - CW and pulsed operation Semiconductor lasers
Tunable diode lasers- tuning methods--high power semiconductor diode lasers- frequency control of laser output- mode locking of semiconductor lasers, large wavelength semiconductor lasers.

Module 4

Ultrafast lasers: Ti:Sapphire Laser-energy levels-pumping mechanism-CPA, Ultrafast fiber lasers-energy level diagram-pumping
Characteristics of Ultrafast lasers-Pulse Duration and Spectral Width- Group velocity dispersion
Measurement of ultrafast laser characteristics- time and frequency domain measurements-intensity autocorrelation -FROG-SPIDER (qualitative idea only)

Generation of attosecond pulses-three step model

References

1. Laser Fundamentals - William T Silfvast, Cambridge University Press, Second Edition(2008) (Text)
2. Principles of Lasers, Orazio Svelto, Springer, Fourth Edition (Text)
3. Barat, Ken, Laser Safety Management , Taylor & Francis, Boca Raton, Fl. (2006)
4. High-Order Harmonic Generation and Attosecond Light Pulses : An Introduction, Anne L'Huillier http://dx.doi.org/10.1002/9783527677689.ch10
5. M. E. Fermann, "Ultrafast fiber oscillators", in Ultrafast Lasers: Technology and Applications (eds. M. E. Fermann, A. Galvanauskas, G. Sucha), Marcel Dekker, New York (2003), Chapter 3, pp. 89–154
6. W. Sibbett et al., "The development and application of femtosecond laser systems", Opt. Express 20 (7), 6989 (2012), doi:10.1364/OE.20.006989
7. Frequency-Resolved Optical Gating: The Measurement of Ultrashort Laser Pulses, Rick Trebino, Springer Science+Business Media , LL C (2002)
8. Lasers:The Power and Precision of Light, Jean-Claude Diels and Ladan Arissian, WILEY Verlag GmbH & Co 2011
9. Ultrashort Laser Pulse Phenomena : Fundamentals, Techniques, and Applications on a Femtosecond Time Scale, Jean-claude Diels, Wolfgang Rudolph, Academic Press, 2nd Edition (2006)

20-351-0703 LAB I - PHOTONICS LAB - I

20-351-0704 LAB II - ELECTRONICS LAB - I

20-351-0705 SEMINAR / VIVA

20-351-072X - Elective I

20-351-072X - Elective II

SEMESTER VIII

20-351-0801 NONLINEAR OPTICS

Course Outcomes

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

1. Utilizing the concepts of nonlinear susceptibilities, predict the frequencies generated by nonlinear optical processes. *(Apply)*
2. Comprehend how phase-matching and index matching are related. *(Analyze)*
3. Analyze the theory of Second Harmonic Generation and parametric oscillations. *(Analyze)*
4. Explain the theory behind Optical Phase Conjugation and its applications in image processing and distortion correction. *(Understand)*
5. Explain the theory of nonlinear scattering mechanisms. *(Understand)*
6. Outline the theory behind Self Focussing and Self Induced Transparency, and the propagation of optical solitons. *(Understand)*
7. Explain the nonlinear absorption processes such as Saturable Absorption, Reverse Saturable Absorption, Multiphoton Absorption and its applications. *(Understand)*
8. Analyze the theory of nonlinear Fabry-Perot etalon, optical bistability and its applications. *(Analyze)*

Module 1

Non-linear polarization, non-linear wave mixing, physical origin of non-linear optical coefficients, susceptibility tensors, propagation of EMW through 2nd order nonlinear media, SHG, second order nonlinear materials, phase matching conditions
OPA and OPO frequency conversion- basic equations, backward wave parametric amplification and oscillation in three wave mixing

Module 2

Third order nonlinearity- third order susceptibility tensor, Degenerate four wave mixing , Phase conjugate optics- properties of phase conjugate light, Distortion correction theorem, Generation of phase conjugate light, FWM in optical Kerr media, coupled mode formulation, Experiments involving OPC- resonators with OPC mirror, Imaging through distorting medium, Image processing through FWM

Module 3

Nonlinear scattering processes: SRS-Quantum mechanical description of Raman scattering, Raman cross section and gain, SRS described by non-linear polarization, Anti Stokes Raman Scattering, CARS- FWM
Self action effects- intensity dependent refractive index
Self-induced transparency- pulse area theorem, self focusing- Threshold condition conditions for self focusing

Module 4

Nonlinear absorption- Two photon Absorption, Experimental set up to detect TPA-single beam TPA, TPA assisted ESA, Multiphoton absorption, Applications of nonlinear absorption, Multiphoton spectroscopy, saturable and reverse saturable absorbers, optical limiting- Z-scan- theory of closed aperture and open aperture Z- scan . Nonlinear Fabry perot- etalon, NLF as a computing element, Optical Bistability- Absorptive and dispersive 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, Elementals 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 (5th Edition), A Yariv, Oxford University Press, (1997)
6. Nonlinear Optics- Shen, John Wiley Sons (1991)
7. Nonlinear Fibre Optics- Govind P Agarwal, Academic Press, 3rd Edition(1989)
8. Quantum Electronics- A Yariv, John Wiley Sons (1975)
9. Fundamentals of Photonics, B E A Salch, M C Teich, John Wiley Sons, 2nd edition (2007)
10. Physics of nonlinear optics-Guang S He and Song H Lie, world scientific , London (1999)

20-351-0802 DIGITAL SIGNAL PROCESSING AND OPTICAL SIGNAL PROCESSING

Course Outcomes

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

1. Relate the characteristics of various signals *(Understand)*
2. Explain Discrete time signals and Linear Time Invariant systems *(Understand)*
3. Employ sampling and digitization of signals *(Apply)*
4. Analyse signals using Z-transform and Fourier Transform *(Analyze)*
5. Design FIR and IIR filter circuits *(Create)*
6. Make use of different mathematical transforms in optical signal processing *(Apply)*
7. Construct spatial filtering geometries based on Fourier transform property of Lens *(Apply)*
8. Discuss the concepts of optical numerical processing *(Understand)*

Module 1

Characteristics of signals: unit step function, impulse, ramp functions, frequency spectrum of periodic wave functions.

Discrete time signals, LTI systems, transfer functions and impulse response function, convolution theorem- stability consideration, properties of discrete time systems, difference and differential equation representation, concept of causality and stability, recursive & non- recursive systems-realization of structures.

Module 2

Sampling and digitization, Nyquist theorem, Reconstruction of signal, Aliasing, Quantization Z transform and its properties, inverse Z transform Discrete FT and its properties, FFT, decimation in time and frequency.

Two dimensional Z-transform, Digital fillers, IIR and FIR filters, design considerations- Realization of FIR & IIR filters- comparison of FIR & IIR filters.

Module 3

Fresnel Transform, Hilbert transform, Mellin transform, Two dimensional Fourier Transform, convolution and correlation. Effect of lens on wavefront. FT properly of lens, OTF. Time and space integrating architecture, spectrum analysis, Vanderlugt filter.

Module 4

Image spatial filtering. SLMs AO. MO, EO and LC based SLMs, Optical numerical processing. Simple arithmetic evaluation of polynomials. Optical implementation of matrix vector multiplication, double integration, partial differential equations.

References

1. Signal processing using optics- B G Boone,Oxford Univ Press, (2000)(Text).
2. Optical computing-D G Feitelson.,MIT Press, (2001) (Text)
3. The Fourier Transform And its Applications to Optics-P M Duffieux, John Wiley Sons 2nd Ed, (1983)
4. Contemporary optics- Thyagarajan & Ghatak, Mc Millian India, (1981) 51
5. Digital signal processing-Proakis JG Manolakis,Prentice Hall of India, 3rd edition(2002)(Text)
6. Digital signal processing –P Ramesh Babu, 4th edition, Scitech publications (2008)
7. Digital signal processing-A Nagoor Kani, RBA publications
8. Modern digital and analog communication systems Lathi B P, CULT OXFORD, (1998).
9. Digital image processing- B Jahane, Springer verlag, (1997).

20-351-0803 LAB - I PHOTONICS LAB - II

20-351-0804 LAB - II ELECTRONICS LAB - II

20-351-0805 - SEMINAR /VIVA

20-351-082X - Elective III

20-351-082X - Elective IV

SEMESTER IX

20-351-0901 OPTICAL COMMUNICATION

Course Outcomes

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

1. Describe the properties and advantages of optical communication *(Understand)*
2. Classify different types of optical sources, their features, and properties *(Understand)*
3. Classify different types of optical receivers, their features, and properties *(Understand)*
4. Analyse the functions of optical amplifiers and wavelength division multiplexing *(Analyse)*
5. Illustrate various optical network topologies and their applications *(Understand)*
6. Design and prepare optical power loss/gain, and rise-time budget with various line coding *(Apply)*

Module 1

Evolution of Optical Communication, Evolution of fiber types, guiding properties of fibers, crosstalk between fibers, dispersion properties of fibers, nonlinear properties of optical fibers, SRS, SBS, Intensity dependent refractive index. Characterization of materials for fibers, fiber perform preparation, fiber drawing, Optical cable design, cable structures, connectors, splicing

Module 2

Optical sources- LED, structures, materials, quantum efficiency, power, modulation-Laser Diode, Modes and threshold conditions, laser diode rate equations, external quantum efficiency, resonant frequencies, laser diode structures and radiation patterns, single mode lasers, modulation of laser diodes, temperature effects

Module 3

Photodetectors, photodetector noise, signal to noise ratio, optical receiver operation, error sources, receiver configuration, digital receiver performance calculations, preamplifier types, High impedance and Trans impedance amplifiers, analog receivers

Module 4

Digital transmission systems, Point to point links, link power budget, rise time budget, line coding, coherent systems, heterodyne and homodyne detection, WDM concepts and components, operational principle of WDM, Optical Amplifiers, semiconductor optical amplifiers, Erbium Doped Fiber Amplifiers, Gain and Power Conversion Efficiency, Soliton communication, basic principle, Optical Network, Network topologies, Basic ideas of SONET and SDH networks, RF over fiber

References

1. Optical Fiber Communications Principles and Practices- J M Senior, Prentice Hall India (1994) (Text)
2. Optical Fiber Communications – Gerd Keiser, 4th Ed (2006) (Text)
3. Optical Networks: A Practical Perspective- Rajeev Ramaswami, Kumar Sivarajan, Galen Sazaki, Third Edition, Morgan Kaufmann Publishers, (2009)
4. Optical Fiber Communication- J Palais, Prentice Hall International, (1988)

20-351-0902 LAB I - PHOTONICS LAB - III

20-351-0903 LAB II - COMPUTATIONAL PHOTONICS LAB

20-351-0904 SEMINAR / VIVA

20-351-092X Elective V

20-351-092X Elective VI

20-351-092X Elective VII

ELECTIVE COURSES

20-351-0721 ADVANCED QUANTUM MECHANICS

Course Outcomes

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

1. Recall the classical idea of rotation and angular momenta. *(Understand)*
2. Understand rotations and angular momenta in quantum mechanics. *(Understand)*
3. Apply Schrodinger's equation to treat many particle systems. *(Apply)*
4. Analyse the energy levels of electrons by the interaction of charged particles with the magnetic field. *(Analyse)*
5. Apply the idea of quantization to study the quantization of electromagnetic fields and quantum field theory. *(Apply)*
6. Apply Dirac equation to study the intrinsic spin of elementary particles. *(Apply)*

Module 1

Rotations in classical physics. Rotations in quantum mechanics, infinitesimal rotations, finite rotations, properties of rotation operator, Euler rotations, representation of the rotation operator, rotation matrices and the spherical harmonics.
Addition of angular momenta, Clebsch-Gordan coefficients, eigenvalues of J^2 and J_z, calculation of Clebsch-Gordan coefficients. Coupling of orbital and spin angular momenta, spin orbit functions, addition of more than two angular momenta.

Module 2

Many particle systems: Schrodinger equation, interchange symmetry, system of distinguishable non-interacting particles, system of identical particles, exchange degeneracy, symmetrisation postulate, constructing symmetric and anti-symmetric functions, systems of identical non-interacting particles, wave functions of two, three and many particle systems, the Pauli exclusion principle, the exclusion principle and periodic table.

Module 3

Effect of magnetic fields on central potentials: effect of magnetic field on charged particle, the normal Zeeman Effect. Perturbation theory: spin-orbit coupling, anomalous Zeeman effect. Interaction of atoms with radiation: classical treatment of incident radiation, quantization of electromagnetic field, Transition rate for absorption and emission of radiation, transition rates within dipole approximation, electric dipole selection rule, spontaneous emission.

Module 4

Relativistic quantum mechanics - Klein-Gordon equation, plane wave solutions, interpretation of KG equation, Dirac equation, Dirac matrices, plane wave solution, positron theory, spin of Dirac particles. Spin magnetic moment, the spin-orbit energy, introductory ideas in Quantum Field Theory. Necessity of a field view, Klein- Gordon field as harmonic oscillators.

References

1. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley & Sons (2001) (Text)
2. Quantum Mechanics, G. Aruldhas, Prentice Hall India (2004) (Text for module 4)
3. An Introduction to Quantum Field Theory, Michael E. Peskin and Daniel V. Schroeder, Westview Press (1995) (Text for field theory part)
4. Quantum mechanics, P. M. Mathews and K. Venketesan, Tata McGraw Hill (2006)
5. Advanced Quantum Mechanics- J. J. Sakurai, Pearson Education (2006)
6. Quantum Mechanics - Thankappan V. K. , New Age International (P)Ltd, 2nd Ed. (2003)
7. Lectures on Quantum Field Theory 2nd Ed., Ashok Das, World Scientific Publishing Company, (2008)

20-351-0722 ADVANCED ELECTROMAGNETIC THEORY AND COMPUTATIONAL METHODS

Course Outcomes

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

1. Recall Maxwell's equations and electromagnetic waves in vacuum *(Remember).*
2. Understand wave propagation in media and dielectric response of materials *(Understand).*
3. Understand retarded potential *(Understand).*
4. Apply the idea of retarded potential to study the field due to time varying configurations *(Apply).*
5. Analyse the field of electromagnetic systems by plotting them using octave software *(Analyze).*
6. Evaluate the field of complex electromagnetic geometries using electromagnetic simulations *(Evaluate).*

Prerequisites: Boundary value problems in electrostatics, Maxwell's equations, Constitutive relations, Electromagnetic boundary conditions, Electromagnetic waves.

Module 1

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 2

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 3

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.
Dipole antenna, Fundamental Antenna parameters, Half-wave dipole, Antenna array and diffraction.
Rayleigh and Mie scattering, Mie modes, Mie modes in dielectric particles and their antenna properties.
Antenna modes in metallic particles of simple geometry, Dark and bright modes.

Module 4

Computational methods in electromagnetics: Simple systems and analytical solution: field of a homogeneous sphere placed in a quasi-static electric field. Discrete dipole approximation (DDA), Boundary element method (BEM). Finite difference time domain method (FDTD), finite element method (FEM).

References

1. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley (2009).
2. Principles of Nano-optics, Lukas Novotny and Bert Hecht, Cambridge University Press (2006).
3. Introduction to Electrodynamics, David J. Griffiths, Prentice Hall of India, 4th Ed. (2012).
4. Plasmonics: Fundamentals and Applications, Stefan A. Maier, Springer (2007).
5. Absorption and Scattering of Light by Small Particles, Craig Bohren and Donald Huffman, John Wiley and Sons (1998).
6. Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Ed. Wiley (2016).
7. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House (1995).
8. David B Davidson - Computational electromagnetics for RF and microwave engineering- Cambridge University Press (2011).
9. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson,Springer-Verlag New York (2013).
10. Discrete-Dipole Approximation for Scattering Calculations, Bruce T. Draine and Piotr J. Flatau, JOSA A 11, 1491-1499 (1994).
11. The Boundary Element Method for Electromagnetic Problems, C. A. Brebbia, R. Magureanu, Engineering Analysis, 4, 178-185 (1987).

20-351-0723 NANOPHOTONICS

Course Outcomes

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

1. Describe the photon propagation through mediums of different dielectric constants and electron propagation under various interaction potentials. *(Understand)*
2. Express the quantum confinement effects in optical properties of materials *(Understand)*
3. Examine plasmonic effects in metal nanoparticles *(Apply)*
4. Explain various methods for nanostructure fabrication. *(Understand)*
5. Calculate the size of nanoparticles using x-ray technique and electron microscopy *(Analyze)*.
6. Describe Photonic crystals *(Understand)*
7. Manipulate nanostructures to enhance secondary radiation *(Apply)*.

Module 1

Foundations for nanophotonics; photons and electrons: similarities and differences, Confinement of photons and electrons, Propagation through a classically forbidden zone: Tunneling, Localization under a periodic potential: Bandgap, Cooperative effects for photons and electrons, Nanoscale optical interactions, Nanoscale confinement of electronic interactions, Quantum confinement effects, Nanoscale electronic energy transfer. Near-field interaction and microscopy; Near-field optics, Near-field microscopy, Nanoscale enhancement of optical interactions.

Module 2

Quantum confined materials: Quantum wells, Quantum wires, Quantum dots, Quantum rings, Manifestations of quantum confinement, Optical properties, Quantum confined stark effect, Dielectric confinement effect.
Nanoplasmonics: optical response of metals, Plasmons, Optical properties of metal nanoparticles, Size dependent absorption and scattering, Coupled nanoparticles, Metal- dielectric core-shell nanoparticles. Local electromagnetic fields in metal nanoparticles,

Metamaterials.
Experiential Learning: simulate energy spectrum of a potential well with infinite and finite walls.

Module 3

Growth Methods for Nanomaterials, MBE, MOCVD, LPE, Laser-Assisted Vapor Deposition (LAVD). Characterization of Nanomaterials, X-Ray diffraction, X-Ray photoelectron spectroscopy (XPS), Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), RHEED, EDS, Scanning probe microscopy (SPM), Scanning tunneling microscopy (STM).
Demonstration: LAVD, calculate particle size from XRD and compare it with the size estimated by TEM, AFM working.

Module 4

Photonic Crystals: Basics concepts, Bandgap and band structures in two and three dimensional lattices. Periodic structures in nature, Experimental methods of fabrication, Photonic crystal fibers (PCF).
Plasmonic enhancement of secondary radiation; classification of secondary radiations, Enhancement of emission and scattering of light, Local density of states in plasmonic nanostructures, Hot-spots in plasmonic nanostructures, Raman scattering enhancement in metal–dielectric nanostructures, Luminescence enhancement in metal–dielectric nanostructures
Experiential Learning:: Photoluminescence spectra of Eu^{3+} ions in sol–gel films containing silver nanoparticles.

References

1. Nanophotonics :P N Prasad, Wiley interscience (2003) (Text)
2. Introduction to Nanophotonics, Sergey V Gaponenko, Cambridge University Press,

2010 (Text)
3. Principles of Nanophotonics, M Ohtsu, K Kobayashi, T Kawazoe, T Yatsui and M Nuruse, CRC Press, 2008.
4. Devices, Circuits and Systems: Nanophotonics, P P Yupapin, K Srinuanjan, S Kamoldilok, Pan Stanford Publishing, 2013.

20-351-0724 OPTICAL SENSOR TECHNOLOGY

Course Outcomes

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

1. Compare the principles of measurement used in different sensing schemes. *(Understand)*
2. Examine the application of important interferometric techniques in high precision measurements *(Analyze)*
3. Analyze the features and applications of a variety of optical fiber sensors used for the sensitive measurements of various physical and chemical parameters. *(Analyze)*
4. 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)*
5. Examine the role of optical micro-cavities for sensing applications. *(Understand)*
6. Explain some emerging sensors based on photonic crystal fibers and fiber loop ringdown spectroscopy *(Understand)*

Module 1

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 and lidar equation

Module 2

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 ref index (liquid) measurement, radius of curvature, focal length

Module 3

Optical fibre sensors - general features- type of OFS- intrinsic and extrinsic sensors-major classification based on modulation; Transmissive & Reflective FOS and applications; simple optical fibre based sensors for displacement, temperature and pressure measurements

Light transmission in microbend 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:

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

Module 4

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:

1. *Michelson, Mach Zehnder fiber optic sensors (using 3 dB couplers)*
2. *Whispering gallery mode sensing using optical microcavities.*

References

1. Optical measurement techniques and applications- P. K. Rastogi. Artech House (1997) (Text)
2. Fibre Optic Sensors principles and applications - B. D. Gupta, NIPA (2006)
3. Optical Sensors: Basics and Applications, Jörg Haus, Wiley-VCH, GmBH (2010)
4. Optical fiber sensors (Volume 4)-Applications,Analysis & Future trends, (Ed.) Brian Culshaw
5. Optical Fibre sensors, components and subsystems Vol. 3- Brain Culshaw and John Dakin, Artech House Inc. (1996)
6. Fundamentals of Fibre Optics in Telecommunications and Sensor Systems- B. P. Pal, Wiley Eastern (1994)
7. Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002
8. Optics - Ajoy Ghatak, Tata Mc Graw Hill, 3rd Ed (2005)
9. Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001
10. Vollmer, Frank, and Y. Deshui. Optical Whispering Gallery Modes for Biosensing. Springer: Berlin, Germany, 2020.
11. Duong Ta, Van, et al. "Whispering gallery mode microlasers and refractive index sensing based on single polymer fiber." Laser & Photonics Reviews 7.1 (2013): 133-139.
12. Fiber Loop Ringdown — a Time-Domain Sensing Technique for Multi-Function Fiber Optic Sensor Platforms: Current Status and Design Perspectives, *Sensors* 2009, *9*, 7595-7621

20-351-0821 QUANTUM OPTICS

Course Outcomes

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

1. Outline the concept of quantized electromagnetic field *(Understand)*
2. Illustrate the concept of coherent states and squeeze states *(Understand)*
3. Explain optical coherence, photon correlation and photon statistics *(Understand)*
4. Summarize the techniques for generation of squeezed light and its applications *(Understand)*
5. Analyse the concepts of hidden variable, entanglement and interferometric measurements *(Analyze)*
6. Discover the interaction between atoms and quantized fields. *(Analyze)*

Prerequisite: Advance level knowledge in Quantum Mechanics (20-351-0721 ADVANCED QUANTUM MECHANICS)

Module 1

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

Module 2

Photon counting measurements, Classification 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 3

EPR argument, experimental studies , Bell's inequalities in quantum optics , nondemolition measurements, quantum coherence, Entanglement and interferometric measurements.

Module 4

Deflection of atoms by light, Kapitza- Dirac effect, Optical Stern-Gerlach experiment, Interaction between Atoms and quantized fields- dressed fields, Jaynes - Cummings model.

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 Press (2004) (Text)
3. Introductory Quantum Optics Christopher Gerry and Peter L knight, Cambridge University [Text]
4. Optical Coherence and quantum optics, Leonard Mandel, Emil Wolf, Cambridge University Press, 2nd Edition (2013)

5. Fundamentals of Quantum Optics- John R Klauder and ECG Sudarshan, Dover publication (2006)
6. Quantum Optics- Werner Vogel, Dirk-Gunnar Welsch, Wiley VCH,3rd edition(2006)

20-351-0822 BIOPHOTONICS

Course Outcomes

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

1. Understand the basic theory and science of interaction of light with cells and tissues, optical imaging techniques, to analyze different optical biosensors and its implications. *(Understand)*
2. Understand material properties of photo sensitizers used for photodynamic therapy.*(Understand)*
3. Examine different tissue engineering strategies using light *(Analyze)*
4. Analyze the role of various optical geometries in bio sensing. *(Analyze)*
5. Understand the basic concepts of optical tweezers and practical implementation *(Understand)*

Module 1

Photobiology; interaction of light with ISPls with ISPls and tissues, Photo-process in Biopolymers-human eve and vision, Photosynthesis; Photo-excitation free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.
Optical coherence Tomography, Fluorescence, resonance energy transfer imaging.

Module 2

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark-field and differential interference contrast microscopy, Florescence, confocal and multi-photon microscopy, STED microscopy.

Module 3

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, planar waveguides, Flow Cytometry: basis, fluorochromes for flow cytometry, DNA analysis.
Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon photodynamic therapy. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration, femto-second laser surgery.

Module 4

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, laser for Genomics and Proteomics, semiconductor Quantum dots for bioimaging, Metallic nano-particles and nano-rods for bio-sensing, Photonics and biomaterials: bacteria as bio-synthesizers for photonics polymers.

References

1. Introduction to biophotonics P.N. Prasad Wiley Interscience (2003) (Text)
2. Biomedical Photonics A handbook T.Vo Dinh (CRC Press) (2002)

20-351-0823 OPTO-MECHANICAL ENGINEERING

Course Outcomes

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

1. Understand the principles and materials required for opto-mechanical systems *(Understand).*
2. Design an optical configuration utilizing basic optical components such as lenses and mirrors *(Apply)*
3. Construct opto-mechanical drawings for different optical components *(Apply)*
4. Design and set up basic opto-mechanical configurations on the optical table *(Apply)*
5. Analyse and investigate basic opto-mechanical tasks such as mechanical deformation and optical stability using commercial software and tools *(Analyse)*
6. Design and accomplish opto-mechanical mounting systems and fixtures *(Apply)*

Module 1

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 2

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 3

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 4

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. Ahmad, Anees - Handbook of Optomechanical Engineering-CRC Press (2017)

2. Matrices and Tensors for Physicists - A W Joshi, New Age International (1995)
3. Paul Yoder, Daniel Vukobratovich - Opto-Mechanical Systems Design, Volume 1_ Design and Analysis of Opto-Mechanical Assemblies. 1-CRC Press (2015)
4. Keith J. Kasunic - Optomechanical Systems Engineering -Wiley (2015)

20-351-0921 INDUSTRIAL PHOTONICS

Course Outcomes

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

1. Understand about various fiber optic components. *(Understand)*
2. Understand different optical networks. *(Understand)*
3. Examine photonic packet switching, *(Analyze)*
4. Analyze the role of various tools for fiber optic assembly. *(Analyze)*
5. Understand the basic concepts of fiber optic assembly *(Understand)*

Module 1

Optical fiber transmission, fiber components-couplers, isolators, circulators, multiplexers, filters, fiber gratings, optical switches, wavelength converters, optical amplifiers, Transmitters, Receivers-Principle of operation, Performance parameters, Specifications, Applications

Module 2

Optical Node-design concepts, broadcast and select network, wavelength routed network, configurations, logical topologies, advantages, demonstrators, LAMBDANET, STARNET, RAINBOW- AON, MONET, DWDM networks, FTTx (x=home, curb, building, antenna)

Module 3

Control and Management Functions- Configuration, Performance and Fault Management- Access network, architecture, deployment- Photonic Packet switching

Module 4

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, 2010 by R Ramaswamy and Kumar N Sivarajan (Text)
2. WDM Optical Networks Concepts, Design and Algorithms, 2002 – Sivaram Murthy and Mohan Guruswamy
3. Understanding Optical Communications by Harry J.R.Dutton (pdf version available at http://cs5517.userapi.com/u133638729/docs/3745fff272ed/Dutton_HJR_Understanding_Optical_Communications.pdf)

4. Optoelectronic Packaging by Alan R. Mickelson, Nagesh R. Basavanhally, Yung-Cheng Lee
5. Wdm Technologies: Active Optical Components, Volume 1 By Niloy K. Dutta, Masahiko Fujiwara
6. Clean Assembly Practices to Prevent Contamination and Damage to Optics by J.Pryatel, W.H.Gourdin (pdf version available at https://e-reports-ext.llnl.gov/pdf/328839.pdf)

20-351-0922 PHOTONIC BANDGAP STRUCTURES AND METAMATERIALS

Course Outcomes

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

1. Comprehend the basic theory underlying photonic crystals and metamterials *(Understand)*
2. Explain how light can be manipulated using photonic bandgap structures and metamaterials *(Understand)*
3. Design simple photonic crystals based on required performance. *(Analyze)*
4. Illustrate the design considerations for various metamterials *(Apply)*

Pre-requisites: Basic understanding of electromagnetic theory, basics of material science including electrical, magnetic and optical properties of materials

Module 1

Electromagnetism in mixed dielectric media- macroscopic Maxwell's equations-electromagnetism as an Eigenvalue problem-general property of harmonic modes-scaling properties of Maxwell's equations

Discrete translational symmetry- photonic band structures-rotational symmetry and irreducible Brillouin zone-time reversal invariance- Bloch wave propagation velocity

Module 2

1D Photonic crystals- multilayer film- physical origin of photonic band gaps- the size of the band gap-evanescent modes in PBG

Two dimensional Photonic crystals-localization of light by point defects-linear defects and waveguides-surface states- preliminary concepts of 3D PBG structures-crystals with complete PBG-localization at a point defect and linear defect

Experiential Learning: *Simulation of 1-D photonic crystal structures using TMM method*

Module 3

Applications of Photonic crystals-periodic dielectric waveguide-two dimensional model-symmetry and polarization-quality factor of lossy cavities- photonic crystal slabs-rod and hole slabs- designing a mirror-designing a cavity-narrow band filter

Module 4

Optical Metamaterials- optical properties of metal dielectric composites-electric and magnetic metamaterials-negative index metamaterials-nonlinear optics using metamaterials

Experiential Learning: Simulation of transmission properties of certain metamaterials

References

1. Photonic Crystals: Molding the Flow of Light, John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn & Robert D. Meade, Princeton University Press, Second Edition (2008) (Text)
2. Optical Metamaterials Fundamentals and Applications, Wenshan Cai, ,Vladimir Shalaev, Springer New York (2010) ISBN 978-1-4419-1151-3 (Text)
3. Photonic Crystals: The Road from Theory to Practice, Steven G. Johnson, John D Joannopoulos, Springer New York (2002)
4. Tutorials in Metamaterials (Series in Nano-Optics and Nanophotonics), Edited by Mikhail A. Noginov, Viktor A. Podolskiy, CRC Press, 1st Edition (2012) ISBN-13: 978-1420092189

20-351-0923 HOLOGRAPHY AND SPECKLE METROLOGY

Course Outcomes

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

1. Summarize the physical basis of primary phenomena (Interference & Diffraction) for hologram and speckle formation. *(Understand)*
2. Demonstrate the essential requirements to set up different off-axis digital holographic recording schemes and subsequent various numerical reconstruction techniques. *(Understand)*
3. Utilize the concept of holographic Interferometry to perform the precise Interferometric measurements. *(Apply)*
4. Infer the practical uses of holography with detailed descriptions of specific examples such as Holographic diffraction gratings, Holographic filters and Head-up displays. *(Understand)*
5. Examine knowledge about essential theoretical concepts and experimental methods of major speckle metrology techniques such as speckle photography, speckle interferometry and speckle shearing interferometry. *(Analyse)*
6. Explain the origin of Biospeckle phenomenon in biological and non-biological specimens. *(Understand)*
7. Develop biospeckle technique as a feasible nondestructive method to evaluate spatial dynamics of biological specimens such as fruits and vegetables. *(Create)*

Module 1

Theoretical foundation for holography and speckle: preliminaries of wave equations and intensity, two wave interference with different frequency, and different amplitudes, between two plane and collinear waves, Scalar Theory of Diffraction: Kirchhoff Diffraction, Fresnel Diffraction, Fraunhofer Diffraction. Diffraction by Apertures-rectangular and circular.
Experiential Learning: Diffraction: prism/grating, interference: Newton's ring/Michelson interferometer

Module 2

Holography: photography and holography, digital holography - general principles, digital Holographic Recording Process, stability requirements, Reconstruction Methods, classification of holograms,

holographic interferometry, holography applications-Holographic diffraction gratings, Holographic filters, Head-up displays and Head-up displays.
Experiential Learning: Recording and reconstruction of Wavefront/Amplitude division digital holograms.

Module 3

Speckle metrology: Introduction, speckle statistics, Speckle photography, electronic speckle correlation interferometry – formation of correlation fringes and its analysis using digital image processing, in-plane and out of plane configuration, Digital speckle photography, speckle shearing interferometry, Digital speckle shearing interferometry, phase evaluation methods, phase shifting-temporal and spatial, phase unwrapping.
Experiential Learning: Electronic speckle pattern Interferometry/Shearography experimental configuration for viewing deflection profile/deformation analysis using mechanical/thermal loading.

Module 4

Dynamic speckle and its applications: Dynamic speckle/Biospeckle, statistics of biospeckle, first order statistics, spatial contrast and temporal contrast, second order statistics, autocorrelation function, Brier's contrast.
Experiential Learning: Laser speckle analysis for biological samples/ specklegram image processing

References

1. Speckle Metrology. In: Laser Measurement Technology. Springer Series in Optical Sciences, vol 188, Donges A., Noll R. Springer, Berlin, Heidelberg (2015).
2. New Directions in Holography and Speckle, H. John Caulfield and Chandra S. Vikram. American Scientific Publishers (2006).
3. Holographic and Speckle Interferometry, Jones, R., and Wykes, C., Cambridge University Press, London 1983.
4. Speckle Metrology, Sirohi, R. S., Marcel Dekker, New York, 1993.
5. Holography Principles and Applications, Raymond K. Kostuk, CRC press,2019

20-351-0924-LASER SPECTROSCOPY

Course Outcomes

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

1. Explain the basic characteristics of a single mode lasers *(Understand)*
2. Understand various applications of lasers in the identification and characterisation of materials available in small quantities *(Understand)*
3. Analyse the various aspects of control and manipulation of laser beams for selected spectroscopic applications *(Analyse)*
4. Identify specific spectroscopic methods for understanding the structure of complex molecular systems *(Apply)*
5. Understand various applications of lasers in chemistry, biology, medicine and research *(Understand)*

Module 1

Experimental Realization of Single-Mode Lasers, Suppression of Transverse Modes, Selection of Single Longitudinal Modes, Mode selection in the case of broad gain profiles and CW dye laser. Intensity and Wavelength Stabilization, Long-term stabilization of the laser wavelength, Wavelength Tuning of Single-Mode Lasers, Continuous Tuning Techniques, Wavelength Calibration, Linewidths of Single-Mode Lasers.

Module 2

Advantages of Lasers in Spectroscopy, High-Sensitivity Methods of Absorption Spectroscopy, Frequency Modulation, Intra-cavity Laser Absorption Spectroscopy, Cavity Ring-Down Spectroscopy, Fluorescence Excitation Spectroscopy, Photoacoustic Spectroscopy, Optothermal Spectroscopy, Ionization Spectroscopy – photoionization, collision-induced and field ionization, Sensitivity of ionization Spectroscopy

Module 3

Laser magnetic resonance and Stark spectroscopy, Laser-Induced Fluorescence, experimental aspects, applications in Polyatomic Molecules. Nonlinear spectroscopy, Laser Raman spectroscopy-stimulated Raman scattering, Coherent Anti-Stokes Raman Spectroscopy, resonance and surface enhanced Raman scattering.

Module 4

Applications of Laser spectroscopy (qualitative study only)

Applications in Chemistry, Single-Molecule Detection, Laser-Induced Chemical Reactions, Coherent Control of Chemical Reactions, Laser Femtosecond Chemistry, Isotope Separation with Lasers, Applications for environmental research, Atmospheric Measurements with LIDAR, Detection of Water Pollution, Applications in material science, Laser-Induced Breakdown Spectroscopy, Measurements of Flow Velocities in Gases and Liquids, Applications in biology, Energy Transfer in DNA Complexes, Time-Resolved Measurements of Biological Processes, Correlation Spectroscopy of Microbe Movements, Medical applications, Raman Spectroscopy in Medicine, Heterodyne Measurements of Ear Drums, Cancer Diagnostics and Therapy with the HPD Technique, Laser Lithotripsy, Laser-Induced Thermotherapy of Brain Cancer, Foetal Oxygen Monitoring.

References

1. Laser Spectroscopy Vol. 1 Basic Principles, Wolfgang Demtröder, Springer Berlin Heidelberg (2008)
2. Laser Spectroscopy Vol. 2 Experimental Techniques, Wolfgang Demtröder, Springer Berlin Heidelberg (2008)
3. Lasers in Dermatology and Medicine - Dental and Medical Applications, Keyvan Nouri, Springer International Publishing (2018).
4. Lasers in Medicine, Waynant, Ronald W, CRC Press (2001).
5. Laser Spectroscopy and Laser Imaging - An Introduction, Helmut H. Telle, Ángel González Ureña, CRC Press (2018).
6. Introduction to Laser Spectroscopy, Halina Abramczyk, Elsevier Science (2005).

20-351-0925- COMPUTATIONAL MATERIAL SCIENCE

Course Outcomes

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

1. Remember Quantum description of materials *(Understand)*
2. Discuss Hartree Fock and Density Functional theory methods *(Understand)*
3. Extend the DFT knowledge to Molecular dynamics simulations *(Understand)*
4. Practice Energy minimizations techniques and Band structure calculations *(Apply)*
5. Employ DFT calculations to obtain Density of states related properties *(Apply)*.
6. Compare DFT results and experimental data *(Analyze)*.
7. Formulate DFT calculations to develop materials for industry *(Create)*

Module 1

Quantum description of materials, Born-Oppenheimer approximation, Hartree method, Hartree-Fock method, Configuration interaction, Density functional theory (DFT): Thomas Fermi Model, Hohenberg-Kohn theorem, Kohn-Sham equations, Comparison of DFT with Hartree and Hartree-Fock methods, Local density approximation (LDA), Extension to magnetic systems, Generalized gradient approximations (GGAs)

Module 2

LDA+U methods, Self-interaction correction, GW approximations,
Time-dependent density functional theory, Classical Molecular dynamics: Born-Oppenheimer Molecular dynamics, Car-Parinello molecular dynamics, Hellmann-Feynman theorem, Plane wave expansion method, Orthogonalized plane wave method, pseudopotential method, Calculation of total energy, Ultrasoft pseudopotential and projected augmented wave methods, non-periodic systems and the concept of supercell.

Experiential Learning:
1. Calculate the total energy of a molecule (Urea) and a bulk materials (Si) using pseudopotential and DFT formalism.
2. Create a supercell of 1-D (H2 molecule Chain), 2D (graphene) and 3D (NaCl) material.

Module 3

Energy minimization techniques, Band structure calculations and comparison with ARPES, Fermi surface, density of states, local density of states and projected density of states, charge density, Construction of surfaces, Interfaces and superlattices, surface relaxation and reconstruction.

Experiential Learning:
1. Calculate the DOS and band structure of Bulk Silicon and Graphene and compare the data with ARPES data from literature.
2. Calculate the Magnetic moment of Fe bulk in the FM and AFM ordering.
3. Create the (100),(110),(111) and (211) surface of Bulk Cu (1x1 cell) and relax the geometry using DFT

Module 4

Comparison of DFT structure with X-ray crystallography, DFT-surface reconstruction vs STM, Simple IR and Raman spectra of molecules using DFT, Dielectric functions using DFT, DFT

Simulation of: 2D materials, topological insulators, Ferroelectric materials, Spintronic Materials, Battery materials.

Experiential Learning:
1. Calculate the IR and Raman Spectra of H2O molecule
2. Calculate the Voltage of a representative anode material for Li-ion battery (LiFePO4)

References

1. Electronic Structure of Materials, Rajendra Prasad, CRC Press, 1st Edn, 2013 (Text)
2. Materials Modelling using Density Functional Theory, Oxford university press, 1st Edn, 2014 (Text)
3. Electronic structure: Basic theory and practical methods, Richard M Martin, Cambridge University press, 1st Edn, 2004 (Text)
4. Density-Functional Theory of Atoms and Molecules; Robert G. Parr, Weitao Yang, Oxford University Press, 1st Edn (1989).
5. Chemist's Guide to Density Functional Theory; Wolfram Koch, Max C. Holthausen, Wiley-VCH Verlag GmbH, 2nd Edn (2001).
6. Density Functional Theory: A practical introduction, David S Holl and Janice A Steckel, Wiley, 1st Edn (2009)