മഹാത്മാഗാന്ധി സർവ്വകലാശാല, കേരളം

സംഗ്രഹം

ഇന്റഗ്രേറ്റഡ് എം.എസ്.സി പ്രോഗ്രാം ഇൻ ബേസിക് സയൻസസ് - ഫിസിക്സ് - 7 മുതൽ 10 വരെയുള്ള സെമസ്റ്ററുകളുടെ സിലബസ് - അക്കാദമിക് കൗൺസിൽ അംഗീകരിച്ചു - ഉത്തരവ് പുറപ്പെടുവിക്കുന്നു.

അക്കാദമിക് എ 4 സെക്ഷൻ

നമ്പർ. 3601/AC A 4/2025/എം.ജി.യു   പ്രിയദർശിനി ഹിൽസ്,തീയതി: 21.04.2025

പരാമർശം:-1) 25.02.2025 തീയതിയിലെ അക്കാദമിക് കൗൺസിൽ യോഗ മിനിറ്റ്സ് ഇനം നമ്പർ:69/AcA4/1/128952/Integrated Programmes/2021 (PART - II)

ഉത്തരവ്

2021-2022 അധ്യയനവർഷം മുതൽ സർവകലാശാലയുടെ കീഴിലുള്ള അഫിലിയേറ്റഡ് കോളേജുകളിൽ ആരംഭിച്ച ഇന്റഗ്രേറ്റഡ് എം.എസ്.സി പ്രോഗ്രാം ഇൻ ബേസിക് സയൻസസ് - ഫിസിക്സ് പ്രോഗ്രാമിന്റെ 7 മുതൽ 10 വരെയുള്ള സെമസ്റ്ററുകളുടെ സിലബസ് (ഇലക്ടീവ് ഉൾപ്പെടെ) ബോർഡ് ഓഫ് സ്റ്റഡീസ് സമർപ്പിച്ചിട്ടുള്ളത്, ടി പ്രോഗ്രാമിന്റെ അംഗീകാരത്തിനായി അക്കാദമിക് കൗൺസിലിന്റെ പരിഗണനയ്ക്ക് സമർപ്പിക്കുകയും ആയത് 25.02.2025-ന് കൂടിയ അക്കാദമിക് കൗൺസിൽ യോഗം പരാമർശം (1) പ്രകാരം അംഗീകരിക്കുന്നതിന് തീരുമാനിക്കുകയും ചെയ്തു.

തദനുസരണം ഉത്തരവ് പുറപ്പെടുവിക്കുന്നു

ശ്രീജിത്ത് ആർ

അസിസ്റ്റന്റ് രജിസ്ട്രാർ 1 (അക്കാദമിക്)

രജിസ്ട്രാർക്ക് വേണ്ടി

പകർപ്പ്

1. പി എസ് ടു വി .സി /പി.വി.സി
2. പി .എ ടു രജിസ്ട്രാർ/പരീക്ഷ കൺട്രോളർ

3. ഇ എച് 18 /ഇ എ /ഇ ബി /ACC 1 /ACC 2 സെക്ഷനുകൾ
4. പി ആർ ഒ സെക്ഷൻ
5. എ ആർ /ഡി ആർ /ജെ ആർ (പരീക്ഷ/അക്കാഡമിക്)
6. റെക്കോർഡ്‌സ് സെക്ഷൻ /ഫയൽ കോപ്പി/ സ്റ്റോക്ക് ഫയൽ

ഉള്ളടക്കം

Syllabus of Integrated M.Sc Programme (7th - 10th Semester including Elective Courses) in Basic Sciences - Physics

ഉത്തരവിൻ പ്രകാരം

സെക്ഷൻ ഓഫീസർ

SEMESTER VII
Core 21:IPH7CR01 –Classical Physics - II
Credit:4(72Hours)

Module I (20 hrs)
Hamiltonian and Hamilton's equations of motion, Conservation theorems, Hamilton's equations from variational principle, Principle of least action. Canonical transformations – Harmonic oscillator as example, Symplectic approach, Poisson brackets, Angular momentum Poisson brackets, Liouville's theorem.

Module II (18 hrs)
Hamilton-Jacobi formalism - Harmonic oscillator as example, Separation of variables – Kepler problem as example, Action-angle variables – Harmonic oscillator as example. Perturbation theory: Time-dependent and time-independent, Adiabatic invariants.

Module III (16 hrs)
Chaos : Attractors, KAM theorem, Chaotic trajectories and Liapunov exponents, Henon-Heiles Hamiltonian, Bifurcations, Logistic equation, Fractals and dimensionality

Module IV (18 hrs)
Special Relativity: Einstein's postulates, Geometry of relativity, Lorentz transformations, Structure of space-time, Proper time and proper velocity, Relativistic energy and momentum, Relativistic Kinematics, Relativistic Dynamics.

Text:
1. H. Goldstein, C. Poole and J. Safko, ``Classical mechanics", Third Edition, Pearson (2011).
2. D. J. Griffiths, ``Introduction to Electrodynamics".

References:
1. Michael Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley (1989).
2. V. B. Bhatia , Classical Mechanics, Narosa (1997).
3. Mechanics Vol. I, Landau and Lifshitz, 3rd Edition, Butterworth-Heinemann (1976).

Core 22:IPH7CR02 –Condensed Matter Physics
Credit:3(54Hours)

Module 1
Wave Diffraction and the Reciprocal Lattice (5Hrs)
Diffraction of waves by crystals-Bragg's Law- Scattered wave amplitude-reciprocal lattice vectors- diffraction condition-Laue equations-Ewald construction-Brillouin zones- reciprocal lattice to SC, BCC and FCC lattices-properties of reciprocal lattice- diffraction intensity - structure factor and atomic form factor- physical significance.

Free Electron Fermi Gas (12 Hrs)

Energy levels in one dimension-quantum states and degeneracy- density of states- Fermi-Dirac statistics -Effect of temperature on Fermi-Dirac distribution – Free electron gas in three dimensions- Heat capacity of the electron gas- relaxation time and mean free path - Electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Module II

Energy Bands (8 Hrs)

Nearly free electron model- Origin of energy gap-Magnitude of the Energy Gap-Bloch functions – Kronig-Penney model –Wave equation of election in a periodic potential-Restatement of Bloch theorem-Crystal momentum of an Electron-Solution of the central equations- Brillouin zone- construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - Effective mass of electron - Distinction between conductors, semiconductors and insulators.

Phonons Crystal Vibrations and Thermal Properties (15 Hrs)

Vibrations of crystals with monatomic basis –First Brillouin zone-Group Velocity-Two atoms per Primitive Basis –Quantization of elastic waves – Phonon momentum- Inelastic scattering of phonons.-Phonon Heat Capacity-Plank distribution-Density of States in one and three dimensions-Debye model for density of states-Debye T3 Law-Einstein Model for Density of states- Anharmonic Crystal interactions-Thermal Expansion- Thermal Conductivity-thermal resistivity of phonon gas-Umklapp Processes-Imperfections

Module III

Magnetic Properties of Solids (14 hrs)

Quantum theory of paramagnetism–Hunds rules-crystal field splitting-spectroscopic splitting factor-Cooling by adiabatic demagnetization – Nuclear Demagnetization- Ferromagnetic order-Curie point and the exchange integral-Temperature dependence of the saturation-Magnetization-Saturation Magnetization at absolute Zero-Magnons- Quantization of spin waves-Thermal excitation of Manganons- Neutron Magnetic Scattering- Ferromagnetic order-curie temperature and Susceptibility- Antiferromagnetic order-susceptibility below Neel-Temperature- Ferromagnetic domains-Anisotropic Energy-transition region between Domains-origin of domains - Corecivity and Hysteresis- Single Domain Particles-Geomagnetism and Biomagnetism-Magnetic scope microscopy-Elements of superfluidity.

Textbooks:

1. Introduction to Solid State Physics, Charles Kittel, Wiely, Indian reprint (2015).
2. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)
3. Introduction to Solids, L V Azaroff, McGRAW-HILL BOOK COMPANY, INC.New York (1960)
4. Solid State Physics,R. K Puri & V. KBabber, S Chand & Company Ltd. (1996)

References:

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th IndianReprint (2011).
2. Solid State Physics, R.L. Singhal, KedarNath Ram Nath& Co (1981)
3. Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).
4. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).
5. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)
6. Solid State Physics, Dan Wei, Cengage Learning (2008)

7. Solid State Physics, J S Blackemore, Cambridge University Press (1985)
8.Electronic Properties of Crystalline Solids, Richard Bube, Academic Press New York (1974)

Core 23:IPH7CR03 – Atomic and Molecular Physics - II
Credit:3(54Hours)

Module I
Atomic Spectra (18Hrs)
The quantum mechanical treatment of hydrogen atom- quantum numbers n, l and ml.; spectra of alkali metal vapors, Derivation of spin-orbit interaction energy in hydrogen-like atoms; extension to penetrating orbits; fine structure in sodium atom Normal Zeeman effect; Anomalous Zeeman effect- magnetic moment of the atom and g factor; spectral frequencies; Lande g-formula. Paschen–Back effect, splitting of sodium D-lines; Stark effect, quadratic Stark effect in potassium doublet. L S coupling scheme -spectroscopic terms arising from two valence electrons; terms arising from two equivalent s-electrons; derivation of interaction energy - combination of s and p electrons; Hund's rule, Lande interval rule. The jj coupling scheme in two electron systems, derivation of interaction energy, combination of s and p electrons;Hyperfine structure(qualitative ideas only).

Module II
Microwave Infrared Spectroscopy (18Hrs)
Rotational spectra of rigid diatomic molecules; effect of isotopic substitution; intensity of spectral lines; energy levels and spectrum of non–rigid rotor Information derived from rotational spectra(molecular structure, dipole moment, atomic mass and nuclear quadrupole moment). Vibrational energy of a diatomic molecule- simple harmonic oscillator –energy levels; diatomic molecule as anharmonic oscillator- energy levels; infrared selection rules; spectrum of a vibrating diatomic molecule. Diatomic vibrating rotator –P and R branches; break down of Born-Oppenheimer approximation. Vibrations of polyatomic molecules – fundamental vibrations and their symmetry; overtone and combination frequencies; Analysis by IR techniques- skeletal vibrations and group frequencies.

Module III
Electronic Spectroscopy (10Hrs)
Electronic spectra of diatomic molecules –Born-Oppenheimer approximation, vibrational coarse structure-progressions and sequences; intensity of spectral lines- Franck – Condon principle, Dissociation energy and dissociation products; Rotational fine structure of electronic-vibrational transition; Fortrat parabola; Predissociation.

Mössbauer Spectroscopy (8Hrs)
Mössbauer effect –Theory,Recoilless emission and absorption, Experimental technique, Chemical isomer shift,Magnetic hyperfine interactions, Electric quadrupole interaction, applications

Text Books:

1. Spectroscopy,B.P. Straughan and S. Walker, Vol. 1, John Wiley &Sons
2. Introduction to Atomic Spectra, H.E. White, McGraw-Hill.
3. Fundamentals of Molecular Spectroscopy, Colin N.Banwell and Elaine M. McCash, McGraw-Hill
4. Molecular Structure and Spectroscopy, G. Aruldhas, PHI LearningPvt. Ltd.

Recommended References:

1. Spectroscopy(Vol. 2 & 3),B.P. Straughan and S. Walker, Science paperbacks 1976
2. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw-Hill
3. Introduction to Spectroscopy, D L Pavia, G M Lampman, G S Kriz, and JAVyvyan,Cengage Learning India Pvt Ltd
4. Modern Spectroscopy, J M Hollas, John Wiley
5. Elements of Spectroscopy,Guptha, Kumar, and Sharma,Pragathi Prakash
6. https:// teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/nmr1.htm
7. https://ntpel.ac.in/courses/15101003/downloads/modu21/lecture23.pdf
8. https://www.ias.ac.in/article/fulltext/reso/009/0034-0049
9. https://nptel.ac.in/

Core 24:IPH7CR04 – Mathematical Physics - II
Credit:3(54Hours)

Module 1 Integral transforms (18 hrs)
Fourier Series, Application of Fourier series, Square Wave, Full Wave Rectifier, Fourier Integral, Fourier Transform, Finite Wave Train, Convolution Theorem of parseval's relation, Momentum representation, Harmonic oscillator,
Laplace Transform, Inverse Laplace transform, Applications- Earth Mutation, Damped Oscillator, LCR circuit.

Module 2 Complex analysis (18 hrs)
Functions of a complex variable, Analytic functions, Cauchy-Riemann equation, Integration in a complex plane, Cauchy Theorem, Cauchy‘s integral formulas, Taylor expansion & Laurent expansion, Residue, poles, Cauchy residue theorem, Cauchy‘s principle value theorem, Evaluation of integrals.

Module III Partial differential equations (18 hrs)

Characteristics of boundary conditions for partial differential equation, Solution of partial differential equations by the method of separation of variables in Cartesian, cylindrical and spherical polar coordinates, Solution of Laplace equation in cartesian, cylindrical and spherical polar co-ordinates, Heat equation in Cartesian co-ordinates.

Text Books:-

1. Mathematical methods for Physicists, G.B. Arfken & H.J. Weber 5th edition, Academic Press.
2. Mathematical Physics , V.Balakrishnan,Ane Books Pvt Limited

Reference Books:

1. Advanced Engineering Mathematics E.Kreyszig 7th edition John Wiley
2. Mathematical Physics, B.S.Rajput,Y.Prakash 9th edition Pragati Prakashan
3. Mathematical Physics, B. D. Gupta ,Vikas Publishing House
4. Matrices and tensors in Physics, A.W. Joshi
5. Mathematical Physics , P. K. Chatopadhyay ,New Age International Publishers
6. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons

Core 25:IPH7CR05– Computational Physics
Credit:3(54Hours)

Module1(18hours)

IntroductiontoComputerProgrammingandC++ Basics

Basicconceptsofprogramming-Languageclassification-stepsindevelopinga program - algorithm and flowchart - structure of a C++ program - header files - main function.comments-datatypes-variabletypes- characterset–tokens-identifiers andkeywords-datatypes – constants – variables – declarations – qualifiers-long, short and unsigned declarations- definingarrays - accessing array elements - initializing arrays- one dimensional and two dimensional arrays-expressions-symbolicconstants-inputandoutputoperators/functions-arithmeticoperators–unary-operators-relationalandlogicaloperators-assignmentoperators-incrementanddecrementoperators -conditionaloperators. Sample programmes.

Module2(22hours)

DecisionMaking,Looping and Functions

ifstatement-ifelsestatement-nestedif-elsestatement-elseifladder-switchstatements–looping-for loop - while loop - do-while statements - nested loop structure – break - continue and go tostatements. Elements of functions - different arguments - return values and their types - scope ofvariables - function declaration - function calls - different types /category of functions - functionoverloading. Sample programmes.

Objects and Classes

Basic concept of object oriented programming- benefits of oopsspecifying a class- defining member functions- nesting of member functions – private memberfunctions – deceleration of object- members – arrays of objectsoperator overloading- definingoperator overloading-overloading unary and binary operators. Create user defined data types forcomplexvariablesandvectorsdefinenecessaryoperators and functions, Sample programmes.

Module 3(14 hours)

Microprocessors

Introductiontomicroprocessors-microprocessoroperations(withrelevanceto8085microprocessor):8085busorganization-addressbus-databus-controlbus,internaldataoperations-8085 registers- accumulator- flags-program counter stack pointer, externally initiated operationsThe8085microprocessorarchitecture-pin outandsignals-internalarchitectureof8085microprocessor Machine language- assembly language- high level language. Instruction cycle,machinecycleand Tstate-instructionformat- addressing modes.

TextBooks:

1. Computerfundamentals-P K Sinha(bpbpub.)
2. ObjectorientedprogramminginTurboC++ -RobertLafore(GalgotiaPub.)
3. RameshS.Gaonkar(PenramInt.Pub.)

ReferenceBooks:

1. FundamentalsofMicroprocessorsandMicrocomputers– BRamPub:DhanpatRaiPublications (P) Ltd.(6 th Edn.)
2. MicroProcessorArchitecturesProgrammingandApplications– R.S.Gaonkar,Pub:PenramInternational
3. ObjectorientedprogramminginTurboC++ -RobertLafore(GalgotiaPub.)
4. ObjectorientedprogramminginC++(Balagurusamy)
5. LetusC++,YashvantKanetkar
6. ThecompletereferenceC++,HerbertSchildt

Core Practical: IPH7CP06 – CORE PRACTICAL - XIII

Credit: 2 (72Hours)

(The student has to complete at least 8 experiments)

1. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law.
2. Study the dipole moment of an organic molecule (acetone).
3. Koening’s method-Poisson’s ratio of the given material of a bar.

4. Absorption bands of $KMnO_4$ using incandescent lamp. Determine the wavelengths of the absorption bands. Determine the wave lengths of the absorption bands by evaluating Hartman's constants.
5. Determine the co-efficient of viscosity of the given liquid by oscillating disc method.
6. Determination of Stefan's constant of radiation from a hot body.
7. Ultrasonic-Acoustic-Determine the velocity of ultrasonic waves and elasticity of liquid medium.
8. Calibration of silicon diode as a temperature sensor.
9. To find the band-gap energy of a silicon diode by forward biasing.
10. Resistivity of a semiconductor specimen by Four probe method.
11. Mode constants of a vibrating strip. To determine the first and second mode constants of a steel vibrating strip; Y to be measured by the Cantilever method and frequency of vibration by the Melde's string method.
12. Fraunhoffer Diffraction at a Single Slit.
13. Measurement of absorption coefficient of a given material using laser light.
14. Track width of a CD using laser beam.
15. He – Ne laser- verification of Malus law, measurement of Brewster-angle, refractive index of a material

References:

1. A course of Experiments with He-Ne Laser- R.S Sirohi (2nd Edition) Wiley Eastern Ltd
2. Advanced course in Practical Physics by D Chattopadhyay
3. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Maha
6. Advanced Practical Physics, S.P singh, PragatiPrakasan,
7. Practical Physics, Gupta, Kumar, PragatiPrakasan

Core Practical: IPH7CP07 – CORE PRACTICAL - XIV

Credit: 2 (72Hours)

(The student has to complete at least 5 experiments from each section - μP and C++)

1. μP – Square of a number
2. μP – Square root of a number
3. μP – Largest among the set of numbers
4. μP – Smallest among the set of numbers
5. μP – Hex number to ASCII Hex Code conversion
6. μP – ASCII Hex Code to Hex number conversion
7. μP – Binary to BCD conversion
8. μP – BCD to Binary conversion
9. μP – Square from look up table
10. μP – 16 bit multiplication
11. μP – Sorting (ascending order)
12. μP – Sorting (descending order)
13. μP – Factorial of a number
14. μP – Counting the number of occurrence
15. Computer programming in C++ – Projectile Motion
16. Computer programming in C++ – Radioactive decay and half life
17. Computer programming in C++ – Formation of standing waves
18. Computer programming in C++ – LCR circuit with dc/ac source
19. Computer programming in C++ – Conversion of temperature scale
20. Computer programming in C++ – Solving a quadratic equation
21. Computer programming in C++ – Generation of Fibonacci series
22. Computer programming in C++ – Conversion of a decimal number into binary Number
23. Computer programming in C++ – Simple Pendulum – Calculation of ‘g’ from experimental data
24. Computer programming in C++ – Resistance colour code to numerical value conversion
25. Computer programming in C++ – Sorting the numbers in ascending and descending order

REFERENCES:

1. Computational physics, An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt. Ltd.
2. An Introduction to computational Physics, Tao Pang, Cambridge University Press.
3. Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, R.H. Silsbee & J. Drager, Cambridge University Press.
4. Numerical Recipes: the Art of Scientific Computing, W.H. Press, B.P. Flannery, S.A. Teukolsky & W.T.Vettering, Cambridge University Press

SEMESTER VIII
Core 26:IPH8CR01– Laser and Nonlinear Optics
Credit:3(54Hours)

Module I (18 hours)

Black body radiation, Planck's law, spontaneous and induced transitions, Einstein's coefficients, gain coefficient, gain saturation and hole burning, homogeneous and inhomogeneous broadened systems, laser oscillation conditions, population inversion, three and four level systems, rate equations, optimum output coupling. Optical resonators, rectangular cavity-open planar resonators- spherical resonators, modes and mode stability criteria, losses in optical resonators-quality factor, unstable optical resonators.

Module II (18 hours)

Q-switching, methods of Q-switching- methods, opto-mechanical methods of light electro optic modulation- Pockels and Kerr modulators- magneto- optic modulators, acousto-optic modulators. Giant pulse lasers, mode locking in homogeneously and inhomogeneously broadened systems, passive and active mode locking beam diagnostics and characterization, thermal lensing effect, far field pattern.

Working principle of Ruby laser, dye laser, argon ion laser, tunable solid state lasers. Semiconductor lasers Nd: YAG laser- flash lamp pumped and diode pumped lasers, He-Ne laser, CO2 laser.

Module III (18 hours)

Harmonic generation, nonlinear optical susceptibility tensor, on the physical origins of the nonlinear optical coefficients, electromagnetic formulation of nonlinear interactions, optical second harmonic generation, experimental set up, two photon absorption, parametric generation of light, basic equations of parametric amplification, parametric oscillation, frequency tuning, experimental arrangement, frequency up and down conversion

Text Books

1.Silfvast. W T., Laser Fundamentals, Cambridge University Press, New Delhi, 1998
2. Yariv A, Optical Electronics, 4thEdn, Holt, Rinehart and Winston, 1991
3. Thyagarajan .K&Ghatak A K Lasers, Theory and Applications Macmillan, 1991
4. OrazioSvelto, Principles of Lasers, 4thEdn, Plenum Press, 1998
5. Ammon Yariv, Quantum Electronics 3rdEdn, John Wiley, New York, 1989
6. Govind P. Agrawal, Nonlinear Fiber Optics, 3rdEdn, Academic Press, New Delhi, 2001.
7.Introduction to Photorefractive Nonlinear Optics, PochiYeh, John Wiley &Sons,New York, 1993

References:

1. Koechner (Walter), Solid State Laser Engineering, Springer-Verlag, 1992
2. Bahaa E. A Saleh &Malvin Carl Teich, Fundamentals of Photonics, John Wiley & Sons, 1991
3. Marvin J. Weber, Hand Book of Lasers, CRC Press, 2001
4. Jeff Hecht, The Laser Guide Book, McGraw Hill, 1986
5. Rampal V.V, Photonics, Elements and Devices, Wheeler, Allahabad, 1992
6. Fischer R.A (Ed), Optical Phase Conjugation, Academic Press,San Diego, 1983
7.SinghN.B, Growth and characterization of Nonlinear Optical Materials,Pergamon, 1990
8. R.D. Guenther, Modern Optics, John Wiley & Sons, 1990
9. Robert W Boyd, Non Linear Optics, 2ndEdn, Academic Press, 2003
10. Richard L. Sutherland, Handbook of Non Linear Optics, Marcal Dekker, 1996

Core 27:IPH8CR02– Quantum Mechanics - II
Credit:3(54Hours)

UNIT I (18 hours)
Linear Vector spaces and Angular momentum

Linear Vector Spaces: Inner Product Spaces, Dual Spaces and the Dirac Notation, Subspaces, Linear Operators, Matrix Elements of Linear Operators, Active and Passive Transformations, The Eigenvalue Problem, Functions of Operators and Related Concepts, Generalization to Infinite Dimensions. Angular momentum in three dimensions, Eigenvalue problem of L2 and Lz (excluding advanced topics), Addition of angular momentum, Simple example, General problem, Irreducible tensor operators.

Text Book:
1. Principles of Quantum Mechanics – R. Shankar

UNIT II (18 hours)
Approximation Methods
Time independent perturbation theory (degenerate and nondegenerate cases) - wave function and correction to energy to second order – charged harmonic oscillator in linear electrostatic potential, selection rules and stark effect, Degenerate perturbation theory- first order Stark effect in hydrogen, Variational method - ground state for quartic potential, WKB approximation, WKB wave functions near and away from stationary points.

Text Book:
1. Principles of Quantum Mechanics – R. Shankar

UNIT III (18 hours)
Time evolution and scattering
Ehrenfest theorem., Time dependent perturbation theory, sudden, adiabatic and periodic perturbation, Fermi's Golden rule, Higher order perturbation theory – Schrodinger, Heisenberg and Interaction pictures, Photoelectric effect in hydrogen atom. Scattering amplitude and differential cross section, Green's function, Born approximation, Scattering due to Yukawa and Coulomb potential, Partial wave analysis - hard sphere scattering, resonances.

Text Book:
1. Principles of Quantum Mechanics – R. Shankar

Reference Books
1. Quantum Mechanics – L D Landau & E M Lifshitz
2. Quantum Mechanics - G Aruldas.
3. Introduction to Quantum Mechanics – D. J. Griffith, Pearson

Core 28:IPH8CR03– Electrodynamics – II and Plasma Physics
Credit:3(54Hours)

Module 1

Basics of Electrodynamics (10 hrs)

Electrodynamics: Electromotive force - motional emf - Faraday's law-, electrodynamic equations - displacement current. Uniform sinusoidal time varying fields E and B and Maxwell's equations in free space and matter. Boundary conditions of electric and magnetic field. Conservation laws- continuity equation- Charge conservaion-Poynting's theorem- Maxwell's stress tensor- momentum conservation.

Module II Electromagnetic waves (14 hrs)

Propagation of em waves through linear media- Reflection and transmission of a plane wave at normal - oblique incidence. Electromagnetic waves in a conducting medium. Reflection at conducting surface- frequency dependence of permittivity. Dispersion of electromagnetic waves in conductors and plasma medium

Module III Electromagnetic radiation (18 hrs)

Potential formulation of electrodynamics- Gauge transformations-Coulomb and Lorentz gauge. Continuous charge distribution-Retarded potential-Jefmenko's equation. Point charges-Lienard-Wiechert potentials-Field of a point charge in motion- Power radiated by a point charge. Electric dipole radiation-magnetic dipole radiation-radiation from arbitrary distribution of charges. Radiation reaction-Abraham-Lorentz formula.

Module IV-Relativistic electrodynamics (12 hours)

Relativistic electrodynamics- Structure of spacetime- Four vectors-Proper time and proper velocity- Relativistic energy and momentum-Relativistic dynamics Minkowski force. Magnetism as a relativistic phenomenon. Lorentz transformation of em field- field tensor-electrodynamics in tensor notation. Potential formulation of relativistic electrodynamics.

Recommended textbooks:

1. Introduction to Electrodynamics, David J. Griffiths, PHI.
2. Electromagnetics, John D.Kraus, McGraw-Hill International
3. Classical electrodynamics, J.D Jackson, John Wiley & Sons Inc

Recommended References:

1. Electromagnetic waves and radiating systems Edward C Jordan, Keith G Balamin, Printice Hall India Pvt.Ltd
2. Elements of Electromagnetic, Mathew N. O Sadiku, Oxford University Press
3. Antenna and wave propagation, K.D Prasad, Satyaprakashan, New Delhi
4. Electromagnetism problems with solutions, Ashutosh Pramanik, PHI.

Core 29:IPH8CR04– Nuclear Physics - II
Credit:3(54Hours)

Module I- Nuclear radiations (20 hrs)

Alpha, beta and gamma radiations, properties, determination of E/M of alpha particle, determination of charge of alpha particle, velocity of alpha particle, range of alpha particles, experimental measurements of range of alpha particle, alpha particle disintegration energy, alpha particle spectra, theory of alpha decay, gamow's theory of alpha decay, the nature of beta particle, determination of E/M of beta particle, Kaufmann's experiment, Bucherer's experiment-increase of beta particle mass with velocity, beta ray specta, magnetic spectrographs, origin of line and continuous spectrum, the neutrino theory of beta decay, gamma ray spectra, determination of wavelength of gamma rays, origin of gamma rays, nuclear isomerism, internal conversion, Mossbauer effect.

Module II- Detectors of Nuclear radiations (16 hrs)

Interaction between energetic particles and matter, ionization chamber, solid state detectors, proportional counter, geigermuller counter, the wilson cloud chamber, diffusion cloud chamber, bubble chamber, spark chamber, nuclear emulsions, the scintillation counter, cerenkov counter.

Module III-Nuclear Reactions (18Hrs)

Types of reactions and conservation laws, energetics of nuclear reactions, isospin, Reaction cross sections, Coulomb scattering- Rutherford formula, nuclear scattering, Scattering and reaction cross sections in terms of partial wave amplitudes, Compound-nucleus reactions; Direct reactions, Resonance Reactions. Neutron thermalization.

References

1. Modern Physics, R. MurugesanS.Chand
2. Concepts of Modern Physics, Arthur Beiser, Tata McGraw-Hill Edition
3. Atomic and Nuclear Physics (Ch.2) S.N Ghoshal)S.Chand
4. Atomic and Nuclear Physics (Ch. 14) S.N Goshal
5. Introductory Nuclear Physics, K. S. KraneJohnWiley
6. Elements of nuclear physics, M.L. Pandya, R.P.S Yadav
7. Concepts of Nuclear Physics, Bernard Cohen, Tata McGraw-Hill Edition

Core Practical: IPH8CP05 – CORE PRACTICAL - XV
Credit: 2 (72Hours)

(The student has to complete at least 8 experiments)

1. Ultrasonic Interferometer – ultrasonic velocity in liquids
2. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
3. Determination of forbidden energy gap
4. Determination of Fermi energy of copper
5. Study of ionic conductivity in KCl / NaCl crystals
6. Thermo emf of bulk samples of metals (aluminium or copper)
7. Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
8. Study of variation of magnetic properties with composition of a ferrite specimen
9. Thin film preparation-chemical method
10. Measurement of wave length of He-Ne laser light using ruler.
11. Measurement of thickness of thin wire with laser.
12. Determination of the Plank's Constant by Photo cell.
13. Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
14. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
15. AC bridge circuits: Maxwell's, De Sauty's and Anderson's bridges (any two).

References:

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley
2. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers: Brian S. Mitchell, Wiley
3. Materials Science and Engineering an Introduction, W. D. Callister, Jr., John, Wiley
4. Materials Science and Engineering A First Course 5 ed., V. Raghavan, Prentice Hall of India Pvt. Ltd.

Core Practical: IPH8CP06 – CORE PRACTICAL - XVI

Credit: 2 (72Hours)

(The student has to complete at least 8 experiments)

1. Frank and Hertz Experiment – determination of ionization potential.
2. Michelson Interferometer - λ and dλ / thickness of mica.
3. Oscillating Disc-Viscosity of a liquid.
4. Cauchy's constant of liquid and liquid mixture using hollow prism and spectrometer.
5. Study the variation of voltage with respect to temperature for a semiconducting material and determine the bandgap energy.
6. Study the variation in electrical conductivity with temperature of NaCl / KCl and determine the vacancy migration energy and formation energy of vacancy pairs.
7. Design of passive filter (first and second order) RC circuit.
8. Determine the minority carrier life time of a semiconductor specimen using photoconductive decay method.
9. Determine the dielectric constant of a sheet by using it as a parallel plate capacitor in an oscillator.
10. Determine the dielectric constant of ADP/ KDP crystal using electro-optic effect.
11. Temperature measurement with sensor interfaced to a PC or a microprocessor
12. Study the I-V characteristics, I-P characteristics, modulation bandwidth and output spectrum of an LED.
13. Study the structural and melting transition in KNO_3 using a differential thermal analyzer
14. Generate the interference pattern in Young's double slit- interference and study the variation of intensity with variation of distance of the screen from the slit.
15. Analyze a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.

References:

1. Kenneth H. Rosen, "Discrete Mathematics And Its Applications", 7th Ed,McGrawHill, 2012.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley India, 9th Edition 2011.
3. Thin film phenomena, K.L Chopra, McGraw Hill, New York
4. Crystallography for Solid State Physics: Verma & Shrivastava.
5. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.

SEMESTER IX
Core 30:IPH9CR01– Research Methodology in Physics
Credit:3(54Hours)

Unit I: Science and Research (6 hrs)

Definition – History – Evolution of Scientific Inquiry – Verification versus falsification – Objectivity : Facts, theory and concepts – Philosophy of Science and Technology, Epistemology of sciences – Construction of scientific facts.

Unit II: Introduction to Research Methodology (12 hrs)

Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem Research Design – Need – Features – Inductive, Deductive and Development of models Developing a Research Plan – Exploration, Description, Diagnosis, Experimentation, Determining Experimental and Sample Designs. Analysis of Literature Review – Primary and Secondary Sources, Web sources –critical Literature Review Hypothesis – Different Types – Significance – Development of Working Hypothesis Research Methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive-Inductive, pattern of Deductive – Inductive logical process – Different types of inductive logical methods.

Unit III: Data Collection and Analysis (12 hrs)

Sources of Data – Primary, Secondary and Teritary – Types of Data – Categorical, Nominal & Ordinal. Methods of Collecting Data: Observation, field investigations, Direct studies – Reports, Records or Experimental observations. Sampling methods – Data Processing and Analysis strategies- Graphical representation – Descriptive Analysis – Inferential Analysis- Correlation analysis - Least square method – Data Analysis using statistical package – Hypothesis – testing – Generalization and Interpretation – Modeling.

Unit IV: Scientific Writing (16 hrs)

Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports - Illustrations and tables – Bibliography, Referencing and foot notes – Oral presentation – Planning – Preparation and practice – Making presentation – Use of visual aids – Importance of Effective Communication. Conventions and strategies of Authentication – Citation Style - sheet Preparing Research papers for journals, Seminars and Conferences – Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN. Preparation of Project Proposal - Title, Abstract, Introduction – Rationale, Objectives, Methodology – Time frame and work plan – Budget and Justification

Unit V: Application of Results and Ethics (8 hrs)

Environmental Impacts - Ethical Issues – Ethical Committees – Commercialization – copy right royalty – Intellectual Property rights and patent law – Track Related aspects of intellectual property Rights – Reproduction of published material – Plagiarism – Citation and Acknowledgement – Reproducibility and accountability.

References:

1. Garg.B.L., Karadia, R., Agarwal,F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R.(2008). Research Methodology: Methods and Techniques. Second Edition. New Age International Publishers, New Delhi.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Publications. 2 volumes. 139
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270 p.
5. Day RA (1992) How to write and publish a scientific paper. Cambridge University press. London
6. Hempel,C. Philosophy of Natural science Englewood Cliffs, N.J: Prentice Hall, 1966.
7. Burtt, E.A. The Metaphysical Foundations of Modern Science. London, 2003.
8. Latour, B. & Woolgar. 3. Laboratory Life. The construction of scientific facts. 2nd Edition. Princeton: Princeton University Press.1986
9. Gupta S.P. (2008). Statistical Methods. 37th ed. (Rev)Sultan Chand and Sons. New Delhi. 1470 p.
10. Sundar Sarukkai (2008)Indian Philosophy and Philosophy of Science, Motilal Banarsidass Publishers Pvt.Ltd. New Delhi.
11. Kozak A, Kozak R.A., Staudhammer C.L., and Watts S.B. (2008). Introductory probability and Statistics; Applications for forestry and Natural sciences.CAB International, UK.408p.
12. Downine N.M Basic Statistical Methods. New York:¨Harper and Health Row Publishers.
13. Frank, Harry. Statistics. Concepts and Applications. Cambridge. Althoen, Steven Cambridge University.
14. Leon & Leon (2202). Internet for everyone, Vikas Publishing House.
15. Wadehra, B.L.2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing

Core 31:IPH9CR02–Advanced Quantum Physics

Credit:3(54Hours)

Unit I (12 hrs)

Second quantization : Identical particles, Many body operators, Creation and annihilation operators, Coherent states, Grassmann algebra Quantum statistical mechanics, Physical respones and Green's functions, Approximations,

Unit II (16 hrs)

Feynman path integral, Partition function as path integral, Partition function for many particle systems, Perturbation theory : Wick's theorem, Labeled and unlabeled Feynman diagrams, Frequency and momentum representation, Linked cluster theorem, Observables and Green's functions

Unit III (16 hrs)

Irreducible diagrams and connected Green's functions, Effective potential, Self energy, Dyson's equation, Vertex functions, Stationary phase approximation and loop expansion Zero temperature theory : Feynman diagrams – Observables, Fermion propagators, Diagrams for Fermions, Bosons, Time-ordered diagrams, Zero temperature limit.

Unit IV (10 hrs)

Phases, Phenomenological Landau theory, Broken symmetry, Order parameter: Ising model, Generalizations, Mean field theory: Legendre transform, Ferromagnetic transition for classical spins, Examples.

Text: J. W. Negele, H. Orland ``Quantum Many Particle Systems"

Core Practical: IPH9CP03 – CORE PRACTICAL - XVII

Credit: 2 (72Hours)

(The student has to complete at least 8 experiments)

1) Measurement of thickness of a thin film
2) Study of dielectric properties of a thin film
3) Study of electrical properties of a thin film (sheet resistance)
4) Growth of single crystal from solution and the determination of its structural, electrical and optical properties (NaCl, KBr, KCl etc.)
5) Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal
6) Synthesis of nano particle by Sol-gel method
7) Preparation of glassy materials using Sol-gel technique

8) Michelson Interferometer – Thickness of transparent film
9) Optical absorption coefficient of thin films by filter photometry
10) Determine the Lande g-factor of electron using an ESR spectrometer
11) Compare the optical absorption spectrum of a direct and an indirect band gap semiconductor specimen and estimate the band gap in each case.
12) Study the dielectric measurements of a material as a function of frequency using LCR Q-Meter.
13) Thin film fabrication using dip coating technique and its thickness measurements
14) Preparation of nano colloids by varying PH scale using chemical synthesis
15) Morphological analysis of nano particles using simulation technique and Sherrer equation

References:

1. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley
2. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers: Brian S. Mitchell, Wiley
3. Materials Science and Engineering an Introduction, W. D. Callister, Jr., John, Wiley
4. Materials Science and Engineering A First Course 5 ed., V. Raghavan, Prentice Hall of India Pvt. Ltd.
5. Materials: Introduction and Applications, Witold Brostow and Haley E. Hagg Lobland, Wiley
6. Material science and Processses, A.K Hajara Choudhury, Indian Book Distributing Co

Core Practical: IPH9CP04 – CORE PRACTICAL - XVIII

Credit: 2 (72Hours)

(The student has to complete at least 8 experiments)

1. Experiments using GM counter- absorption co-efficient of beta rays in materials.
2. Magneto-optic effect (Faraday effect)- rotation of plane polarization as a function of magnetic flux density.
3. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.
4. Electrical and thermal conductivity of copper and determination of Lorentz number.
5. XRD – Crystal structure determination Cubic/ Hexagonal
6. XRD – Determination of Crystal size and lattice strain
7. Electrical conductivity of electrolytes using conductivity meter and its PH measurements
8. Calibrate a thermocouple as a temperature sensor.

9. Study the photo conductivity characteristics of a semiconducting material with the variation in light intensity.
10. Study the dependence of Hall coefficient on temperature and nature of majority charge carriers using Hall effect set-up.
11. Determine the average wavelength of sodium D lines and the thickness of a glass slide using a Michelson Interferometer.
12. Determine the band gap energy of germanium using a reverse biased p-n junction diode.
13. Determine the drift mobility of carriers in a semiconductor specimen using Haynes-Shockley experiment.
14. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal.

References:

1. Nonstoichiometry, diffusion and electrical conductivity in binary metal oxides, Per Kofstad, Wiley
2. Nonstoichiometric Oxides, O. Toft Sorensen, Academic Press
3. Electroceramics: Materials, Properties, Applications, A. J. Moulson, J. M. Herbert, Wiley
4. Transition Metal Oxides, C.N.R. Rao and B. Raveau, Wiley-VCH
5. Basic Solid State Chemistry, A.R. West, Wiley
6. Structure and Properties of Inorganic Solids, F.S. Galasso, Pergamon Press
7. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education
8. Fundamentals of Materials Science and Engineering: An Interactive e.Text, 5th Edition by William D. Callister and William D. Callister Jr. Wiley

SEMESTER X

Semester X is dedicated for Major Project and the Comprehensive Viva-Voce. Both shall be conducted as per the Mahatma Gandhi University regulations for the Integrated Post Graduate Programmes under credit semester system 2020-2021, if it is not mentioned otherwise.

Core Project
IPHXPR01 – PROJECT -MAJOR
Credit: 16 (450 Hours)

The major project shall be designed as research oriented so that the student may get an exposure to his/her area of interest. It also gives them an opportunity to mingle with experts in the field and get hands on different research technologies. The institution (**Parent Institution**) has to tie-up with another reputed firm/institution (**External Institution**) where the student can complete his/her project work. The student should be assigned with both an internal and an external mentor. The internal mentor shall be a teaching faculty of the discipline from the parent institution while the external mentor/guide shall be a scientist/faculty/expert from the external institution where the student does his/her project work.

There is both internal and external evaluation for the major project. Internal evaluation shall be done by the external institution. The external evaluation will be conducted at the parent institution by external examiner at the end of the semester.

For Project – Major

a) Internal (CE)

This has to be done by the external institution and the grade sheet has to be transferred to the parent institution.

No.	Components	Weightage
I	Project Involvement	1
II	Data collection	2
III	Analysis & Result	2
	Total	5

b) External (ESE)

No.	Components	Weightage
I	Relevance of the topic & Data Collection.	3
II	Project Analysis	3
III	Result & Significance	3
IV	Presentation & Dissertation	3
V	Project Viva	3
	Total	15

Core-Viva Voce

IPHXVV02 – COMPREHENSIVE VIVA VOCE

Credit: 4

The purpose of the comprehensive viva-voce is to assess whether the student has attained the desired outcomes of the programme discipline. This is done through a face to face interaction between the examiner and the student. It also helps the student to develop his/her communication skill which is essential for his/her professional development.

There are both internal and external evaluations for the viva-voce. Internal evaluation shall be conducted by the parent department. The external evaluation shall be conducted by external examiner at the time of project (major) evaluation.

For Comprehensive Viva-Voce

a) Internal (CE)

No.	**Components**	**Weightage**
I	Communication/ Presentation	1
II	Topics from all semesters	2
III	Topic of Interest	2
	Total	5

b) External (ESE)

No.	**Components**	**Weightage**
I	Communication/ Presentation	3
II	Topics from all semesters	6
III	Topic of Interest	6
	Total	15

B. ELECTIVE COURSES

SEMESTER VIII
ELECTIVE II - BUNCH B
IPH8ELB1 – Characterisation of Nano Materials
Credit:4(72Hours)

Module1- Growth Techniques of Nanomaterials (15 hours)

Introduction, Top-down vs. Bottom-up Technique, Lithographic Process and its Limitations, Nonlithographic Techniques, Plasma Arc Discharge, Sputtering, Evaporation, Chemical Vapour Deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy, Sol-Gel Technique, Electrodeposition.

Module 2- Characterization Tools of Nanomaterials (25 hours)

X-Ray Diffraction, Small Angle X-Ray Scattering (SAXS), Scanning Probe Microscopy (SPM), Basic Principles of SPM Techniques, The Details of STM, Summary of STM, General Concept and Defining Characteristics of AFM, Scanned-Proximity Probe Microscopes, Laser Beam Deflection, AFM Cantilevers, Piezoceramics, Feedback Loop, Alternative Imaging Modes, AFM and Biology, Electron Microscopy, Resolution vs. Magnification, Scanning Electron Microscope, SEM Techniques, Electron Gun, Specimen Interactions, Environmental SEM, Transmission Electron Microscope, High Resolution TEM, Contrast Transfer Function.

Module 3- Photoluminescence Spectroscopy (17 hours)

Photoluminescence Spectroscopy- Band Gap Determination- Impurity Levels and Defect Detection- Recombination Mechanisms- Compositional Analysis and Contaminant Identification- Free Carrier Properties of Semiconductor Materials- Microprobe and Mapping of Heterogeneities, Light Scattering Methods- Multi-Angle Static Light Scattering (MALS)- Dynamic Light Scattering (DLS)- Zeta Potential, Ultraviolet-Visible Spectroscopy- Applications of UV-Vis

Module 4- Nanolithography (15 hours)

Two-Photon Lithography, Near-Field Lithography, Near-Field Phase-Mask Soft Lithography, Plasmon Printing, Nanosphere Lithography, Dip-Pen Nanolithography, Nanoimprint Lithography, Photonically Aligned Nanoarrays

References

1. Nanophotonics, Paras N. Prasad
2. Introduction to Nanoscience and Nanotechnology, K. K. Chattopadhyay and A. N. Banerjee.
3. Nanoscience and Nanotechnology, K. K. Choudhary.

IPH8ELB2 – Quantum Field Theory
Credit:4(72Hours)

Module 1

Classical Fields, Klein-Gordon and Dirac fields (18 Hours)

Relativistic notation, Classical Lagrangian field theory, Quantized Lagrangian field theory, The real Klein-Gordon field, The complex Klein-Gordon field, Covariant commutation relation, The meson propagator, The Dirac field, The number representations for fermions, The Dirac equation, Second quantization, The spin-statistics theorem, The fermion propagator.

Text Book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapter-2, 3 and 4.
2. Classical Mechanics, H. Goldstein, Second Edition, Narosa Publishing House, 2001, chapter-12.

Module 2

The S-Matrix expansion and Feynman Diagrams (18 Hours)

Natural dimensions and units, The S-Matrix expansion, Normal-ordered product and Time-ordered product, Wick’s theorem, Feynman diagrams in configuration space, Feynman diagram in momentum space, The first order terms S(1), Compton scattering, Electron-electron scattering, Closed loops, Feynman rules for QED, Leptons.

Text Book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapters-6, 7.

Module 3

Radiative Corrections and Regularization (18 Hours)

QED processes in lowest order perturbation theory, Radiative corrections, The second order radiative corrections of QED, The photon self-energy, The electron self-energy, External line renormalization, The vertex modification, The infrared divergence, Higher-order radiative corrections, Renormalizability, Regularization, Feynman parameterization, Cut-off regularization, Dimensional regularization.

Text Book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapters-8, 9, 10.

Module 4

Gauge Theories and Path Integrals (18 Hours)

The simplest gauge theory:QED, QCD – Colour confinement, Global phase invariance and colour conservation, SU(3) gauge invariance, Quantum chromodynamics, Green functions, Feynman diagrams and rules, The perturbation expansion, The vacuum amplitude, The photon propagator, Connected Green functions, Functional and Grassmann fields, The generating functional, Functional integration, Classical fields, Grassmann generators, Grassmann fields, Path integrals - generating functional, Free and interacting fields, Free electromagnetic fields, Free spinor fields, Perturbation theory.

Text book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapters-11, 12, 13.

References:

1. Quantum Field Theory, F. Mandl, G. Shaw, Second Edition, Wiley, 2010.
2. An Introduction to Quantum Field Theory, M. E. Peskin, D. V. Schroeder, CRC Press, 2019.
3. Quantum Theory of Fields, 3 Volume set, S. Weinberg, CUP, 2008.
4. Lectures on Quantum Field Theory, A. Das, Second Edition, World Scientific, 2020.
5. Quantum Field Theory for the Gifted Amateur, T. Lancaster, Oxford University Press, 2014.
6. Quantum Field Theory in a Nutshell, A. Zee, Second Edition, Levant Books, 2012
7. Quantum Field Theory, L. W. Ryder, Cambridge University Press, 1996
8. A First book of Quantum Field Theory, A. Lahiri, P. B. Pal, Narosa Publishing House, 2007.
9. Introduction to Quantum Field Theory, H. Nastase, Cambridge University Press, 2019.

SEMESTER IX
ELECTIVE III - BUNCH C
IPH9ELC1 – Advanced Materials Science
Credit:4(72Hours)

Module 1- Ceramics (17 hours)

Glasses, Glass-Ceramics, Clay Products, Refractories, Abrasives, Cements, Advanced Ceramics, Ceramic Phase Diagrams, Mechanical Properties-Brittle Fracture of Ceramics, Stress-Strain Behavior, Mechanisms of Plastic Deformation, Miscellaneous Mechanical Considerations, Glass Properties, Heat Treatment of Glasses, Heat Treatment of Glass Ceramics.

Module 2- Polymers (21 hours)

Structures of Polymers- Hydrocarbon Molecules, Polymer Molecules, The Chemistry of Polymer Molecules, Molecular Weight, Molecular Shape, Molecular Structure, Molecular Configurations, Thermoplastic and Thermosetting Polymers, Copolymers, Stress-Strain Behavior Macroscopic Deformation, Viscoelastic Deformation, Fracture of Polymers, Miscellaneous Mechanical Characteristics, Deformation of Semicrystalline Polymers, Factors that Influence the Mechanical Properties of Semicrystalline Polymers, Deformation of Elastomers, Crystallization, Melting, The Glass Transition, Melting and Glass Transition Temperatures, Factors that influence Melting and Glass Transition Temperatures, Plastics, Elastomers, Fibers, Miscellaneous Applications, Advanced Polymeric Materials, Polymerization, Polymer Additives.

Module 3- Composite Materials (17 hours)

Large-Particle Composites, Dispersion-Strengthened Composites, fiber-reinforced composites, Influence of Fiber Length, Influence of Fiber Orientation and Concentration, The Fiber Phase, The Matrix Phase, Polymer-Matrix Composites, Metal-Matrix Composites, Ceramic-Matrix Composites, Carbon-Carbon Composites, Hybrid Composites, structural composites-Laminar Composites, Sandwich Panel.

Module 4- Properties of Materials (17 hours)

Electrical- Electrical Conductivity, Energy band structure if Solids, Electron Mobility, Conduction in Ionic materials, Dielectric materials. Magnetic Properties- The influence of temperature on magnetic behavior, domains and hysteresis, Soft and hard magnetic materials, magnetic storage, superconductivity. Optical Properties- Electromagnetic radiation, light interaction with solids, Luminescence, photoconductivity, lasers, optical fibre in communication.

Reference

1. Callister's Materials Science and Engineering, Second Edition, R. Balasubramaniam.

IPH9ELC2 – Advanced Quantum Field Theory
Credit:4(72Hours)

Module 1
Quantum Chromodynamics (QCD) (18 Hours)
Gluon fields-The generating functional, The Faddeev-Popov method, Gauge fixing and ghosts, The QCD Lagrangian-the generating functional, free fields, Perturbation theory-Wick's theorem and propagators, The perturbation expansion, the vertex factors, The three-gluon vertex, The four-gluon vertex, The ghost-gluon vertex, Feynman rules for QCD, Renormalizability of QCD, Asymptotic freedom-electron-positron annihilation, Two-jet events, Three-jet events, The renormalization scheme, the electron propagator, The photon propagator, Charge renormalization, The renormalization group equations, Scale transformations, the running charge, the strong coupling constant, colour factors, Null diagrams, Renormalization of the coupling constant-the quark selfenergy, The gluon self-energy, The quark-gluon vertex corrections, The running coupling.
Text Book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapter-14 and 15.

Module 2
The Electro-weak Theory (18 Hours)
Weak interactions, Leptonic weak interactions, The free vector boson field, Feynman rules for the IVB theory, Decay rates, Muon decay, The leptonic decay of the W boson, Neutrino masses, Neutrino oscillations, Difficulties with the IVB theory, Gauge theory of weak interactions, The gauge-invariant electroweak interaction, Properties of the gauge bosons, Lepton and gauge

boson masses, Spontaneous symmetry breaking, The Goldstone model, The Higgs model, The standard electroweak theory, Lagrangian density in the unitary gauge, Feynman rules, Electron-positron annihilation, The Higgs boson, Higgs boson decays. The standard model particle physics.

Text Book:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010, Chapters-16, 17, 18 and 19.

Module 3

CP Violation in QCD (8 Hours)

QCD as Non-abelian gauge theory, Symmetries in QCD-Discrete symmetries, Continuous symmetries, Instaton solutions, Homotopy classes and examples, Non-trivial Euclidean action gauge fields, Winding number vacua, Instantons, Chirality non-conservation, Theta-vacua, The strong CPproblem, Energy of the theta-vacua, The Peccei-Quinn mechanism - Toy model, Axions in the toy model, Problems with the standared Peccei-Quinn model, Alternative models with a Peccei-Quinn symmetry.

Text Book:

1. Vaccum Structure of the Strong Interaction with a Peccei-Quinn Symmetry, W. J. den Dunnen, vrije Univesiteit Amsterdam, 2008, Chapters-2, 3, 4, 5.

Module 4

Supersymmetry (Susy) (14 Hours)

Notations for the components of Weyl spinors, Building of Lorentz invarients, Index-free notation, Sigma indices notation, Physics of Weyl, Majorana and Dirac spinors, Building of simplest supersymmetric Lagrangian, Auxiliary fields, Wess-Zumino model, on-shell and off-shell susy, 4d Superspace and extended susy, Susy breaking, Minimal supersymmetric standared model (MSSM).

Text book:

1. Supersymmetry DeMYSTiFied, P. Labelle, McGraw-Hill Professional, 2010. Chapters-3, 4, 5, 6,14, 15.
2. Introduction to Supergravity, H. Nastase, 2011, arXiv:112.3502[hep-th], Lectures-3, 4.

Module 5

Supergravity (Sugra) (14 Hours)

Vielbein, Spin connection, Anti-de Sitter space, Degrees of freedom counting- Off-shell, On-shell, N=1 4d on-shell supergravity, Coset theory and Rigid superspace, N=1 4d supergravity off-shell, N=1 4d supergravity in superspace, Superspace actions and coupling supergravity with matter.

Text book:

1. Introduction to Supergravity, H. Nastase, 2011, arXiv:112.3502[hep-th], Lectures-2, 5, 7, 9, 10, 11.

References:

1. Quantum Field Theory, F. Mandl, G. Shaw, 2nd Edition, Wiley, 2010.

2. An Introduction to Quantum Field Theory, M. E. Peskin, D. V. Schroeder, CRC Press, 2019.
3. Quantum Theory of Fields, 3 Volume set, S. Weinberg, 2008.
4. Lectures on Quantum Field Theory, A. Das, Second Edition, World Scientific, 2020.
5. Quantum Field Theory for the Gifted Amateur, T. Lancaster, Oxford University Press, 2014.
6. Quantum Field Theory in a Nutshell, A. Zee, 2012
7. Quantum Field Theory, L. W. Ryder, 1996
8. A First book of Quantum Field Theory, A. Lahiri, P. B. Pal, Narosa, 2007.
9. Introduction to Quantum Field Theory, H. Nastase, 2019.
10. Supersymmetry and Supergravity, Revised edition, J. Wess and J. Bagger, Princeton Series in Physics, 103.
11. Introduction to Supersymmetry and Supergravity, P. West, Revised and extended second edition, World Scientific, 1990.
12. Supersymmetry DeMYSTiFied, P. Labelle, McGraw-Hill Professional, 2010.
13. Supergravity, D. Z. Freedman, A. Van Proeyen, Cambridge University Press, 2012

ELECTIVE IV - BUNCH D
IPH9ELD1 – Advanced Semiconductor Physics
Credit:3(54Hours)

ModuleI

FET-Field-EffectTransistor(20hours)

Introduction– Types of Field-Effect Transistors- Junction Field-Effect Transistor –Formation of Depletion Region in JFET – Operation of JFET – Characteristics ofJFET– DrainCharacteristics–EffectofGate-to-SourceVoltageonDrainCharacteristics– TransferCharacteristics–JFETParameters–MathematicalExpressionforTransconductance– Comparisonbetween Junction Field EffectTransistors and Bipolar Junction Transistor. MOSFET- Types of MOSFET – Depletion-TypeMOSFET – Working of a Depletion-Type MOSFET – Drain Characteristics ofDepletion TypeMOSFET– TransferCharacteristicsforDepletionTypeMOSFET, Enhancement-TypeMOSFET– Draincharacteristicsforenhancementtype MOSFET-TransferCharacteristicsofEnhancement-TypeMOSFET.

ModuleII

Amplifiers, Oscillators, Time Base Generators (12hours)

Needforbiasing-Stabilization-Voltagedividerbias. SinglestagetransistorAmplifiers-CEamplifier-amplificationfactors.Decibel system,VariationsinAmplifiergainwithfrequency.OscillatoryCircuits-LCoscillators – Hartley Oscillator, Colpit’s Oscillator, RC oscillators - Phase shiftOscillator.
General features of a time base signal – Types of time base circuits – Methods of Generating a time base Waveform – Exponential Sweep circuit – Sweep Circuit using Transistor Switch– A Transistor Constant Current Sweep – Miller Sweep Circuit –Bootstrap Sweep Circuit –Current

Time Base Generator.

ModuleIII
FET Amplifiers (13 Hours)
Introduction-Biasing the FET- Biasing the JFET-Gate Bias-Self Bias-Setting a Q-Point - Setting a Q-Point Using Load Line – Biasing Against Device Parameter Variation – Voltage Divider Bias – Source Bias – Current Source Bias – Biasing the Enhancement Type MOSFET ‘s – Biasing the Depletion Type MOSFET ‘s -The Field –Effect Transistor amplifier-Common source Amplifier, Analysis of Common Source Amplifier-Effect of AC load on amplifier parameters-Effect of external source resistance on Voltage gain, Common Drain Amplifier-Analysis of Common Drain Amplifier-Common Gate Amplifier- Analysis of Common Gate Amplifier

References:

1. A text of Applied Electronics, R. S. Sedha - S. Chand (2005)
2. Basic Electronics-Solid State, B. L. Thereja- S. Chand (2005)
3. Electronic Devises and Circuits, J. B. Gupta-S.K. Kataria & Sons
4. Electronic Instrumentation and Systems, R. G. Gupta, Tata McGraw-Hill (2004)
5. Electronic Components and Materials, Madhuri A Joshi- Wheeler Publishing (1996)

IPH9ELD2 – General Relativity
Credit:3(54Hours)

Module 1
Special Relativity (8 Hours)
Lorentz transformations, Time dilation, Particle dynamics, Energy and Momentum, Vectors and Tensors (Linear combinations, Direct products, Contraction, Differentiation), The Minkowski tensor, The Levi-Civita tensor, The Zero tensor, Lorentz invariant equations, The field-strength tensor, Invariant forms of the Maxwell equations, Energy-Momentum tensor, Spin.
Text Book:

1. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, S. Weinberg, Chapter-2

Module 2
General Theory of Relativity (18 Hours)
Unit 1: Principle of Equivalence and Principle of General Covariance
The principle of equivalence- Gravitational forces, Relation between and , The Newtonian limit, Time dilation in a gravitational field, Principle of general covariance- Vectors and tensors, Tensor algebra, Tensor densities, Transformation of affine connection, Covariant

differentiation, Gradient, Curl, and Divergence, Effects of gravitation- Particle mechanics, Electrodynamics, Energy-momentum tensor, Curvature- Definitions of curvature tensor, Uniqueness of curvature tensor, Round trips by parallel transport, Algebraic properties of curvature tensor.

Unit 2 : Einstein's Field Equations

Derivation of Einstein's field equations, The Brans-Dicke theory, Coordinate conditions, The action principle, The matter action, General definition of energy-momentum tensor, The gravitational action.

Text Book:

1. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, S. Weinberg, Chapters-3,4,5,6,7,12

Module 3

Applications of General Theory of Relativity (18 Hours)

Unit 1: Classical Tests of Einstein's Theory

The general static isotropic metric, The Schwarzschild solution, Other metrics, General equations of motion, Unbound orbits: Deflection of light by the sun, Bounded orbits: Precession of perihelia, Radar echo delay, The Schwarzschild singularity.

Unit 2: Gravitational Radiation

The weak-field approximation, Plane waves, Energy and momentum of plane waves, Generation of gravitational waves, Quadrupole radiation, Detection of gravitational waves (basic ideas only), Gravitational lensing.

Text Book:

1. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, S. Weinberg, Chapters-8,10

Module 4

Modified Gravity Theories (10 Hours)

f(R) theories of gravity, Kaluza-Klein gravity, Lovelock gravity, Gauss-Bonnet gravity, Horava-Lifshitz gravity, Gauge gravity theories, Topological gravity, Emergent gravity. String theory as a candidate for quantum gravity, Loop quantum gravity, etc. (Only basic ideas and motivations, and corresponding action of such theories required). Non-minimally coupled gravities (Jordan frame action), Conformal transformations and scalar field theories of gravity (Example: Conversion of Starobinsky action to scalar field action via conformal transformations)

Text book: References 8-18

References:

1. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, S. Weinberg, Wiley India, 1972
2. Gravitation : Foundation and Frontiers, T. Padmanabhan, Cambridge University Press, 2010
3. Gravitation, C. W. Misner, K. S. Thorne, J. A. Wheeeler, D. I Kaiser, Princeton University Press, 1973.
4. Spacetime and Geometry: An Introduction to General Relativity, S. M Carroll, Cambridge University Press, 2013
5. General Relativity, R. M Wald, Overseas, 2006.
6. A First Course in General Relativity, B. Schutz, Cambridge University Press, 2022
7. Gravity: an Introduction to Einstein's General Relativity, Pearson Education India, 2014.
8. f(R) Theories of gravity, T. P Sotiriou, V. Faraoni, arXiv:0805.1726 [gr-qc],
9. Kaluza-Klein Gravity, J. M Overduin, P. S. Wesson, arXiv:gr-qc/9805018, Phys.Rept.283:303-380,1997.
10. Lovelock, David (1971). "The Einstein Tensor and Its Generalizations". *Journal of Mathematical Physics* (AIP Publishing) **12** (3): 498–501.
11. P. G. S Fernandes, P. Carrilho, T. Clifton, D. J. Murlyne, The 4D Einstein-Gauss-Bonnet Theory of Gravity: A Review, Class. Quantum Grav. 39 (2022) 063001.
12. A. Wang, Hořava Gravity at a Lifshitz Point: A Progress Report, Int. J. Mod. Phys. D26 (2017) 1730014.
13. E. P Verlinde, On the Origin of Gravity and the Laws of Newton, *JHEP* 04 (2011) 029
14. E. Witten, Topological Gravity, Physics Letters B, Volume 206, Issue 4, 2 June 1988, Pages 601- 606.
15. J. Bennet, A pedagogical review of gravity as a gauge theory, arXiv:2104.02627 [gr-qc]
16. C. Rovelli, Loop Quantum Gravity, *Living Reviews in Relativity.* ***11*** *(1): 5*
17. S. Mishra, D. Muller, A. V Toporensky, On generality of Starobinsky and Higgs inflation in the Jordan frame, arXiv:1912.01654v3 [gr-qc]
18. B. Zwiebach, A first Course in String Theory, Cambridge University Press, arXiv:1912.01654v3 [gr-qc]2004.

ELECTIVE V - BUNCH E
IPH9ELE1 – Nano Optics and Nano Photonics
Credit:3(54Hours)

Module 1- Foundations for Nanophotonics (18 hours)

Photons and Electrons: Similarities and Differences, Free-Space Propagation, 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, Axial Nanoscopic Localization, Lateral Nanoscopic Localization, Nanoscale Confinement of Electronic Interactions, Quantum Confinement Effects, Nanoscopic Interaction Dynamics, New Cooperative Transitions, Nanoscale Electronic Energy Transfer, Cooperative Emission.

Module 2-Plasmonics and Photonic Crystals (18 hours)
Metallic Nanoparticles and Nanorods, Metallic Nanoshells, Local Field Enhancement, Subwavelength Aperture Plasmonics, Plasmonic Wave Guiding, Applications of Metallic Nanostructures, Radiative Decay Engineering.

Basics Concepts of photonic crystals, Theoretical Modeling of Photonic Crystals, Features of Photonic Crystals, Methods of Fabrication, Photonic Crystal Optical Circuitry, Nonlinear Photonic Crystals, Photonic Crystal Fibers (PCF), Photonic Crystals and Optical Communications, Photonic Crystal Sensors

Module 3-Nanophotonics and the Marketplace (18 hours)
Nanotechnology, Lasers, and Photonics, Nanonetchnology, Worldwide Laser Sales, Photonics, Nanophotonics, Optical Nanomaterials, Nanoparticle Coatings, Sunscreen Nanoparticles, Self-Cleaning Glass, Fluorescent Quantum Dots, Nanobarcodes, Photonic Crystals, Photonic Crystal Fibers, Quantum-Confined Lasers, Near-Field Microscopy, Nanolithography, Future Outlook for Nanophotonics, Power Generation and Conversion, Information Technology, Sensor Technology, Nanomedicine.

Reference

1. Nanophotonics, Paras N. Prasad, Wiley

IPH9ELE2 – Cosmology
Credit:3(54Hours)

Module 1
Basic Cosmology (4 Hours)
Basic Cosmolgy, Friedmann equations, Observables and measurements, Present status of observational cosmolgy.

Module 2
Early Universe Physics (20 Hours)
Standared Big bang cosmology, Puzzles of standared big bang cosmology: Flatness problem, Horizon problem, Unwanted relic problem, Structure formation issue etc., Inflationary paradigm and model building, Structure formation, Quantum fluctuations and origin of perturbations, Observational parameters, Thermal history of universe. Post-inflationary Perturbation, Evolution of super-Hubble and sub-Hubble modes, Sachs-Wolfe effect, Baryon accoustic oscillations, Estimation of power spectrum.

Module 3
Cosmic Microwave Background Radiation (CMB) (10 Hours)
Cosmic microwave backgroun radiation, Non-Gaussianity, Generation of CMB anisotropies and links to observations, Isocurvature modes, Polazization and lensing in CMB, Cosmological parameters from CMB.

Module 4

Inflationary Model Building (10 Hours)

Inflationary model building and typical examples, Inflationary model building in Supergravity typical examples, Eta-problem in supergravity, Alpha-attractor models of inflation.

Module 5

Present Universe (10 Hours)

Dark energy, Observational features, Major candidates for dark energy, Model building, reconstruction of parameters. Dark matter, Observational evidence for dark matter, Spiral galaxies, Galaxy clusters, Structure formation, Dark matter candidates.

References:

1. S. Weinberg, Cosmology, Oxford University Press, 2008.
2. S. Dodelson, Modern Cosmology, Academic Press, 2003.
3. A. R. Liddle and D. H. Lyth, Cosmological Inflation and Large Scale Structure, Cambridge University Press, 2000.
4. A. Liddle, An Introduction to Modern Cosmolgy, 3rd Edition, Wiley, 2015.
5. D. H. Lyth and A. R. Liddle, The Primordial Density Perturbation, Cambridge University Press, 2009.
6. E. J. Copeland, M. Sami and S. Tsujikawa, Dynamics of Dark energy, arXiv:hep-th/0603057, Int.J.Mod.Phys.D15:1753-1936,2006.
7. L. Amendola and S. Tsujikawa, Dark Energy Theory and Observations, Cambridge University Press, 2010.
8. E. Martinez-Gonz’lez and P. Vielva, The Cosmic Microwave Background Anisotropies:Open Problems (chapter), Springer.
9. M. Yamaguchi, Supergravity Based Inflation Models: A Rewiew, arXiv:1101:2488[astroph.CO].
10. R. Kallosh and A. Linde, Universality Class in Conformal Inflation, arXiv:1306.5220 [hepth]
11. R. Kallosh and A. Linde, Escher in the Sky, arXiv:1503.06785 [hep-th]
12. J. Martin, C. Ringevel, V. Vennin, Encyclopaedia Inflationaries, arXiv:1303.3787 [astroph.CO].