RADHA GOVIND UNIVERSITY

RAMGARH, JHARKHAND

DEPARTMENT OF PHYSICS

COURSE CURRICULUM FOR UNDERGRADUATE COURSES UNDER CHOICE BASED CREDIT SYSTEM

M.Sc Physics

With effect from 2018-2020

RADHA GOVIND UNIVERSITY

RAMGARH

Course Structure

Semester – I			Course Credits	Hours /Week	Full Marks	End Sem + Mid Sem
S. No.	**Course Code**	**Course-Name**				
1.	PHY F-01	Mathematical Physics, Classical Mechanics & Computational Techniques	5	5	100	70+30
2.	PHY C-02	Quantum Mechanics-I and Laser Physics	5	5	100	70+30
3.	PHY C-03	Electrodynamics and Plasma Physics	5	5	100	70+30
4.	PHY C/P-04	Optics Lab.	5	5	100	70+30
Semester – II			**Course Credits**	**Hours /Week**	**Full Marks**	**End Sem + Mid Sem**
S. No.	**Course Code**	**Course-Name**				
1.	PHY S-05	Experimental Methods & Techniques	5	5	100	70+30
2.	PHY C-06	Quantum Mechanics-II and Nano Physics	5	5	100	70+30
3.	PHY C-07	Atomic Physics & Statistical Mechanics	5	5	100	70+30
4.	PHY C/P-08	Electronics Lab.	5	5	100	70+30
Semester – III			**Course Credits**	**Hours /Week**	**Full Marks**	**End Sem + Mid Sem**
S. No.	**Course Code**	**Course-Name**				
1.	PHY A-09	Basic Applied Physics	5	5	100	70+30
2.	PHY C-10	Solid State Physics & Digital Electronics	5	5	100	70+30
3.	PHY C-11	Nuclear and Particle Physics & Molecular Spectroscopy	5	5	100	70+30
4.	PHY C/P-12	Electronics Lab.	5	5	100	70+30
Semester – IV			**Course Credits**	**Hours /Week**	**Full Marks**	**End Sem + Mid Sem**
S. No.	**Course Code**	**Course-Name**				

1.	PHY E-13	Electronics Special – I/ Condensed Matter Physics Special-I	5	5	100	70+30
2.	PHY E-14	Electronics Special – II/ Condensed Matter Physics Special-II	5	5	100	70+30
3.	PHY E/P-15	Electronics Special Practical/ Condensed Matter Physics Special Lab	5	5	100	70+30
4.	PHY D-16	Project/Dissertation	5	5	100	50+50

Regulation:

Each Paper (Theory & Practical) carries full marks of 100, out of which Sessional exam (Internals) will carry 30 marks and End Semester Exam (External) will carry 70 marks.

Sessional (Internals) Exam: 20 marks and General awareness, Attendance and General Discipline: 10.

End Semester Exam: 70 marks. The end semester exam will consist total nine questions and question number one will be compulsory (short answer type each to be answered in about 50 words). Candidates will be required to answer any four questions from remaining eight long answer type questions. All questions will carry equal marks. Duration of paper will be of 3 hours.

Semester – I

PHY F-01 (Mathematical Physics, Classical Mechanics & Elements of Computational Techniques) (credit: 05, lectures: 60)

Unit-1

Mathematical Physics:

Matrices and Tensors:- Introduction of matrices through rotation of co-ordinate systems, Orthogonal, Hermitian, Unitary, Null and Unit matrices, Singular and Non-singular matrices, Inverse of a matrix, Trace of a matrix, Eigenvalues and Eigenvectors, Diagonalization. Tensorial character of physical entities, Covariant, Contravariant and Mixed tensors, Contraction, Quotient rule, Differentiation, Kronecker tensor, Pseudo tensor, Symmetric and Anti symmetric tensors. **(10 Lectures)**

Unit-2

Special Functions: Legendre, Bessel, Hermite and Laguerre differential equations and their polynomials, orthogonality. **(8 Lectures)**

Unit-3

Green's Function: Introduction Construction of the Green's function for 1d, 2d and 3d problems. (**5 Lectures)**

Unit 4

Group Theory: Definition and examples of physically important finite groups, Basic symmetry operations and their matrix representations, Multiplication table, Cyclic groups and subgroups, Classes. Reducible and Irreducible representation. (**09 Lectures)**

Unit-5

Classical Mechanics: Generalized coordinates. Lagrangian and Lagrange's equation, Hamiltonian and Hamilton's equation and their applications, Hamilton's principle and characteristic function, Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets. Symmetry, invariance and Noether's theorem. Hamilton – Jacobi equation. Canonical transformation, generating functions, infinitesimal generators, Poisson bracket, Poisson theorems, angular momentum, Principle of Least action. Rigid body dynamics- moment of inertia tensor**. (20 Lectures)**

Unit-6

Elements of Computational Techniques: Root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Solution of First order differential equation using Runge-Kutta method. Finite difference methods. Simulation technique. **(8 Lectures)**

Reference Books :

1. Applied Mathematics for Engineers and Physicists: L.A. Pipes and R. Rarvill.
2. Mathematical Physics: A.K. Ghatak and I. Goyal.
3. Mathematical Physics: Satya Prakash.
4. Mathematical Physics: B.S.Rajput
5. Classical Mechanics: Herbert Goldestien , Pearson Education N.Delhi.
6. Classical Mechanics: S.L.Gupta, V.Kumar & H.V.Sharma – Pragati Prakashan.
7. Classical Mechanics: Rana and Joag.
8. Classical Mechanics: J.C.Upadhyaya
9. Classical Mechanics: Yashwant R. , Waghmare (PHI 1990)
10. Classical Mechanics: S.N. Biswas (Allied Publiser Kolkata)
11. Introductory Methods of Numerical Analysis: S.S.Sastry (PHI)

PHY C- 02 (Quantum Mechanics I and Laser Physics) (credit: 05, lectures: 60)
Quantum Mechanics - I [34 Lectures]

Unit-1
Harmonic Oscillator by Schrodinger equation and by matrix method, Matrix formulation of Quantum Mechanics, Variational methods-Application to ground state of Hydrogen atom and first excited state of harmonic oscillator. WKB approximation. **[8 Lectures]**

Unit-2
Schrodinger, Heisenberg and interaction pictures, their applications to linear harmonic oscillator **[6 Lectures]**

Unit-3
Angular Momentum: Commutation relations for angular operators, Eigen values and Eigenvectors, Pauli spin matrices and spin eigenvectors, addition theorem, Clebsch – Gordon coefficients, angular momentum and rotation, motion in centrally symmetric field, Schrödinger's theory of Hydrogen atom. **[20 Lectures]**

LASER [26 Lectures]
Unit-4 Laser and Holography: Spontaneous and stimulated emission, Einstein A and B coefficients, Basic Principles of Laser, Population Inversion-Two level and Three level Laser system, optical pumping, modes of resonator and coherence length, The Nd^{3+}, YAG laser, The Neodymium Glass laser, The CO2 Laser, Organic Dye lasers, Semi-conductor Laser, Liquid Laser,Requisites for producing LASER light, Q – Switching, Mode locking theory, rate equations (four level LASER and Quasi three level LASER). **[10 Lectures]**

Unit-5
Basic principles and different LASER's: LASER and qualitative description of longitudinal and TE- LASER systems, spin – flip Raman LASER, Plasma recombination LASER. **[9 Lectures]**

Unit-6
Non Linear interaction of light with matter: LASER induced multiphoton process and their application, second order Harmonic generation. **[7 Lectures]**

Reference Books :

1. Quantum mechanics: D.J. Griffiths
2. Quantum mechanics: L.I. Schiff (Mc Graw Hill)
3. Quantum mechanics: T K Thankappan
4. Quantum mechanics: B. Crasman and J D Powell
5. Quantum mechanics: Mathews and J J Sakurai
6. Quantum mechanics: Ghatak and Loknathan
7. Modern Quantum mechanics: J J Sakurai
8. Quantum mechanics: S N Biswas

9. Quantum mechanics: G P Singh
10. Quantum mechanics: G.S. Chaddha
11. LASER Fundamentals: Silfvast (Cambridge University, Press)
12. LASER's: Siegman (Univ. Science Books, USA)
13. Elements of Quantum Optics: Meystre and Sargent (Spriger – Verlag)
14. LASER Physics: Srgent, Scully and Lamb .
15. Essentials of LASER and non – linear optics : Baruah Pragati Prakashan, Meerut)

PHY C- 03 (Electrodynamics and Plasma Physics) (credit: 05, lectures: 60)
Electrodynamics (30Lecture)
Unit-1
Electromagnetic Vector and Scalar Potentials, Wave equation. Lorentz condition. Non-Uniqueness of electromagnetic potentials and concept of gauge**. [6 lectures]**
Unit-2
Electrodynamics of a moving charge and radiating systems: Lienard – Wiechert potentials and derivation of LW potential of a moving point charge. Electric and Magnetic fields due to uniformly moving point charge and accelerated charge. Angular Distribution of Radiation emitted by accelerated charge. Radiation Damping: Abraham Lorentz formula**. [15 Lectures]**
Unit-3
Relativistic Electrodynamics: Four Vectors, Four vectors of charge, current density and E.M. Potentials. Covariance of Continuity equation and Lorentz condition. Transformation equations for the electromagnetic potentials. Invariance of Maxwell field equation. Maxwell's equation in covariance Four Tensor Form. **[09 Lectures]**

Plasma Physics [30 Lectures]
Unit-4
General properties and Fundamental concepts of plasma. Introductory idea of different states of matter.
Kinetic theory of plasma: Boltzmann's equation, Boltzmann – Vlasov Equation, Derivation of moment equations**. [10 Lectures}**
Unit-5
Plasma Characteristics: Fundamental equations of MHD, Debye Shielding and plasma parameter, Plasma oscillations. Expression of Alfven Velocity. **[10 Lectures]**
Unit-6
Plasma confinement: Pinch effect and confinement of plasma. Waves in cold plasma, Wave propagation in magnetized cold Plasma – Appleton – Hartee equation, Atmospheric Whistler, and Faraday rotation. **[10 Lectures]**

Reference Books:

1. Electromagnetic Theory, Chopra & Agarwal
2. Electrodynamics – Gupta, Kumar & Singh
3. Electromagnetic Theory & . Electrodynamics, Satyaprakash
4. Classical Electrodynamics, Jackson (Wiley)
5. Electromagnetic: B. B. Laud (New Age International Publ.)
6. Classical Electrodynamics: P. Sengupta (New Age International Publ.)
7. Plasma Physics: Francis F. Chen (Plenum Press)
8. Plasma Physics: Bittencourt
9. Magnetohydrodynamics: S.I. Pai
10. Plasma Physics by Suresh Chandra, CBS Publishers

PHY C/P- 04: Optics Lab. (credit: 05, Lectures: 60)
Time: 6 hours

1. Determination of wavelength of Laser light using Grating.
2. Determination Of Wavelength Of Laser Light by using vernier calipers
3. Determination of thickness of thin wire using Laser light.
4. Verification of Brewster's Law using spectrometer.
5. Determination of wavelength of Sodium light using Michelson Interferometer.
6. Determination of wavelength of Sodium light using Fabry – Perot interferometer.
7. Determination of resolving Power of a Telescope.
8. Determination of specific rotation of given liquid sample using Polarimeter.
9. Determination of resolving solving power of Prism.
10. Analysis of elliptically polarized light using □/4 plate and Babbinet's compensator.
11. Verification of Rayleigh's criterion for the limit of resolution of spectral lines

    using (a) prism spectrum and (b) grating spectrum.
12. Determination of optical constants of metal in thin film form.

Semester – II

PHY S – 05 (Skill Development Course: Experimental Methods & Techniques) (credit: 05, lectures: 60)

Experimental Methods & Techniques

(60 Lectures) Unit-I

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting, Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

Unit – II

Passive Devices – Resistors – types characteristics – color coding – capacitors – type – characteristics –color coding star and delta connections of resistors and capacitors – chokes – transformers – testing of diodes, transistors and ICs – Multimeter (analog ang Digital) – CRO – waveforms and Lissajous figures – AF and RF oscillators – usage of bread board.

Unit – III

Semiconductor diode – Zener diode – Transistor – Transistor configuration – diode rectifier – half wave and full wave – Bridge rectifier – Diode voltage doubler and multiplier. Regulated power supply, Zener diode voltage regulator [Series and Shunt type] IC Voltage regulators; fixed positive – fixed negative – adjustable.

Unit-IV

Material Characterization & Surface probe techniques: Principle of AFM, STM, SEM and it's applications.

UNIT-V

Scientific Computation and Simulation: Introduction to: Linux Operating System, Linux commands, FORTRAN/C, SCILAB, Gnu plot, Molecular Dynamics, Monte-Carlo, NAMD, VMD.

References Books :

1. Molecular spectroscopy, an Introduction, Jagmohan, Narosa Publication
2. Solid State Physics, Ashcroft/Mermin, Thomson Publishers

PHY C- 06 (Quantum Mechanics II and Nano Physics) (credit: 05, lectures: 60)
Quantum Mechanics II
(45 Lectures)
Unit-1

Approximation method in QM: Time independent perturbation theory, non –degenerate and degenerate cases, Stark effect, Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection, Semi- classical theory of radiation-Einstein A and B coefficients. **[12 Lectures].**

Unit-2

Elementary theory of scattering: Laboratory and Centre of mass reference frames, scattering amplitude, differential scattering cross section and total scattering cross section. Scattering by spherically symmetric potentials, partial wave analysis and phase shifts, Born approximation, Rutherford Scattering. **[15 lectures]**

Unit-3

Relativistic QM: Klein – Gordon equation and its merit and demerit, Dirac equation, probabilities and current densities, Magnetic moment and spin of electron, free particle solution of Dirac equation and interpretation of negative energy states**. [15 Lectures]**

Unit 4: Quantization of EM field: Number representation of fermions and bosons, Creation and annihilation operators, Electromagnetic field in vacuum. **[4 Lectures]**

Nano–Physics

[15 Lectures]

Unit-5

Properties of individual nanoparticles : Metal nanoclusters, magic numbers, modelling of nanoparticles, Bulk to nano transitions, Methods of synthesis, Sol-Gel method, chemical Vapour deposition methods, thermolysis, pulse LASER methods.

Unit-6

Carbon Nanostructures: Nature of carbon clusters, discovery of Fullerenes, Carbon Nanotubes - synthesis, electrical and mechanical properties.

Unit-7

Quantum Wells, Wires and Dots : Preparation of quantum nanostructures, size effects, conduction electron and dimensionality, properties dependent on density of states. DOS in 3-D, 2-D,1-D ,0-D Systems.

Reference Books:

1. Quantum Mechanics: L.I. Schiff (Mc Graw Hill)
2. Quantum Mechanics: T.K. Thankappan
3. Quantum Mechanics: B. Crasman and J.D. Powell (Addison Wesley)
4. Quantum Mechanics: Mathews and Venkateshan
5. Quantum Mechanics: Ghatak and Loknathan
6. Modern Quantum Mechanics: J.J.Sakurai
7. Quantum Mechanics: G. Aruldhas
8. Quantum Mechanics: S. N. Biswas
9. Introduction to Nanotechnology: Pook and Owen
10. Quantum Dots: Jack, Hawylak and Wojs.
11. Introduction to Nanotechnology: Charles P. Poole, Frank J. Owens Wiley Intrersc.
12. Nanotechnology: Basic Sciences and emerging technologies, Mick Wilson, Kamali Kannangara, Geo T. Smith.

PHY C- 07 (Atomic Physics & Statistical Mechanics) (credit: 05, lectures: 60)
Atomic Physics (Quantum Approach):

Unit-1

Quantum states of an electron in an atom, Electron spin, Hydrogen atom spectrum, spectrum of Helium and Alkali atoms, Fine Structures, Relativistic correction for energy levels of Hydrogen,

Spectroscopic terms and selection rules, Hyperfine structure and isotopic shift. Lande's 'g' factor, Lande's interval rule, equivalent and non-equivalent electronic states of two electron systems. Singlet and triplet series of two electron system, Hartee - Fock equation, Series spectra in alkali elements and alkaline earth elements, L – S and J – J coupling, Width of spectral line, Normal and anomalous Zeeman effect, Paschen – Back effect, Stark effect**. [15 lectures].**

Statistical Mechanics (Quantum Approach):

Unit 2

Quantum Ensemble Theory: Micro-canonical Canonical and Grand Canonical ensembles, Phase space, Distribution functions, Partition function and relationship to thermodynamic quantities, Fluctuations in energy, particle density, Pressure and volume, Equivalence of ensembles. entropy of mixing and Gibb's Paradox, Liouvilles Theorem and Density Matrix (Quantum Treatment**). [Lectures 10].**

Unit 3

Quantum Statistics: Equation of state of ideal Fermi and Bose gases, Degenerate electron gas and specific heat, Degenerate Bose gas, Bose-Einstein condensation, Thermal properties of Bose- Einstein gas and liquid He^4, The Lambda transition, Liquid Helium I and II**.[10Lectures]**

Unit 4

Imperfect Gases: Classical and Quantum cluster expansion, Virial equation of state, Virial coefficients in classical limit, Second Virial coefficients for hard-sphere and square-well potentials**.[10 Lectures]**

Unit 5

Phase Transitions: Ising model, Bragg-Williums Approximation, Mean field theories of the Ising model In three, two and one dimensions, Exact solutions in one dimension, Landau theory of phase transition, Critical indices, Scale transformation and dimensional analysis. **[10 Lectures]**

Unit 6

High-Density Gases: Thermo-ionic and photoelectric emission, Spin Para-magnetism, Landau Diamagnetism, Equation of state at very high density, Equilibrium of bodies of large mass, Chandrasekhar mass limit, White dwarf and neutron stars**. [5 Lecture]**

Reference Books:

1. Sinha, S.K., “Statistical Mechanics”,
2. Kerson& Huang, “Statistical Mechanics”,
3. Friedman, H.L., “A Course in Statistical Mechanics”,
4. McQuarrie, D.A., “Statistical Mechanics”,
5. Landau, L, &Liefshitz, “Statistical Mechanics”, Pergaman Press.
6. Statistical Mechanics, R.K.Patharia, Bufferworgh Heinemann
7. Fundamental of Statistical and Thermal Physics, F.Rief, McGraw Hill International Edition.
8. Fundamental of Statistical Mechanics, B.B. Laud, New Age International Pub.
9. R.K.Srivastava&J.Ashok, “Statistical Mechanics”.
10. Hill, T.L., “Statistical Mechanics”,
11. Gupta & Kumar, “Statistical Mechanics”,
12. Agrawal, B.K., Statistical Mechanics.
    a. Atomic Spectra and Atomic Structure, Gerhard Hertzberg.
13. Molecular Structure & Spectroscopy, G. Aruldhas: Prentice Hall of India, New Delhi.
14. Fundamental of molecular spectroscopy,Colin N Banwell & Elaine & M. McCash, Tata Mc Graw- Hill publishing company Limited.
15. Introduction to Atomic, molecular and Laser Physics. D.K. Roy & S.N. Thakur.
16. Introduction to Atomic & Molecular Physics by B. Narayan
17. Statistical Mechanics: Satyaprakash and JP Agrawal
18. Statistical Mechanics: BK Agrawal and M Eisner
19. 19.Fundamental of statistical and Thermal Physics: Rief

PHY C/P- 08 (Electronics Lab) (credit: 05, lectures: 60)
Time : 6 hours.

1. ZENER DIODE – CHARACTERISTICS & STABILISATION
2. FET – Characteristics.
3. MOSFET - Characteristics.
4. Unijunction Transistor – Characteristics.
5. Transistor Amplifier (CE – Mode)
6. Basic Logic gates and from Universal Gates.
7. Characteristics of SCR.
8. Half and full Adder.

Semester – III

PHY A-09: Open Elective: Basic Applied Physics (credit: 05, lectures: 60) [For the students other than M. Sc. physics]

Unit-1

Basic Electronics: Idea of intrinsic and extrinsic semiconductors, p-n junction diode, Zener diode, LED, BJT, FET with their applications, Elementary Boolean algebra, conversion of decimal numbers into binary numbers, Basic and Universal logic gates. **[Lectures 20]**

Unit-2

Laser Physics: Principle of laser action, properties of laser, Idea of He-Ne laser, Ruby laser, CO_2 laser, Dye laser, p-n diode laser with their applications**. [Lectures 20]**

Unit-3

Nanophysics: Idea of nano-technology and nano-science, idea of size effects, idea of quantum well, quantum wires and quantum dots and carbon C_{60}, CVD and PLD methods for the synthesis of nano materials. [**Lectures 10]**

Unit-4

Harvesting of Solar, Wind, Lightening, Ocean and Hydro Energy.

Idea of Quantum mechanics: Wave – particle Duality, Matter Waves, Expression for wavelength, Uncertainty Principle.

Idea of Plasma and its Properties **[Lecture 10]**

Reference Books:

1. Physics of Semiconductor Devices, S. M. Sze, Wiley-Eastern Ltd (1981)
2. Electronic Devices, L. Floyd, Pearson Education New York (2004)
3. Integrated Electronics, J. Milman and C. C. Halkias, McGraw Hill (1972)
4. Semiconductor Devices and Applications, A.Mottershed, New Age Int Pub.
5. LASER Fundamentals: Silfvast (Cambridge University, Press)
6. LASER's: Siegman (Univ. Science Books, USA)
7. LASER Physics: Sergent, Scully and Lamb.
8. Introduction to Nanotechnology: Pook and Owen
9. Introduction to Nanotechnology: Charles P. Poole, Frank J. Owens Wiley Intrersc.
10. Nanotechnology: Basic Sciences and emerging technologies, Mick Wilson, Kamali Kannangara, Geo T. Smith.
11. Crystallography and Solid-State Physics, A. R. Verma and O. N. Srivastava
12. Solid State Physics, A. J. Deckker
13. Introduction to Solid State Physics, Kittel
14. Elements of Solid-State Physics, J. P. Srivastava
15. Solid State Physics Theory, Applications and Problems, S. L. Kakani & C. Hemraja
16. Non –conventional Energy sources by G. D.Roy ,Khanna Publishers New Delhi

PHY C- 10 (Solid State Physics and Digital Electronics) (credit: 05, lectures: 60)

Solid State Physics:

Unit-1

Free electron theory of Metals: Difficulties of the classical theory, free electron model, electronic specific heat, paramagnetic of free electrons**. [4 Lectures]**

Unit-2

Electronic Properties: Electron in a Periodic lattice, Bloch Theorem, Band Theory, Tight Binding, Cellular and Pseudopotential method, Fermi surface, de Haas van Alphen Effect, Cyclotron resonance, Magnetoresistance, Quantum Hall Effect**. [10 Lectures]**

Unit-3

Magnetism: Exchange interaction, Heisenberg model and molecular field theory, spin waves and magnons, Ferri and Antiferromagnetic order, Domains and Bloch Wall energy. **[6 Lectures]**

Unit-4

Dielectrics and Ferroelectrics. Lorentz field equations, Dipole moment, Polarizability, Classification of ferroelectric materials, Landau's theory of phase transitions, anti-ferroelectricity, and piezoelectricity**. [8 Lectures]**

Unit-5

Superconductivity: Occurrence of superconductivity, Destruction of superconductivity by magnetic fields, Basic properties of superconductors, Type-I and Type II superconductors, Meissner effect, Thermodynamics of superconducting transitions, London equations, Josephson effect, BCS theory, High temperature superconductivity. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals. **[12 Lectures**]

Digital Electronics

Unit-6

Digital Systems: Flip-flops (R-S type, T-type, D-type, J-K type, J-K edge triggered, J-K Master/Slave), Shift register, ripple counter, Synchronous counter.

BJT logic families: TTL logic NAND gate circuit, ECL logic OR/NOR gate circuit, analysis and evaluation of logic parameters.

MOS logic families: NMOS inverter circuit and its analysis with linear and non-linear loads, CMOS inverter. **[12 Lectures]**

Unit-7

Electronic Devices: Semi-Conductor Diodes, The continuity equation, Application of the continuity equation for an abrupt pn-junction under forward and reverse bias, Einstein equation, Varacter diode, Schottky diode, Structure, working and derivation of the equation for I-V characteristics of Tunnel diode, Transfer electron devices (Gunn Diode) and Avalanche transit time device (Read, Impatt diodes). **[8 Lectures]**

Reference Books:

1. Crystallography and Solid-State Physics, A. R. Verma and O. N. Srivastava
2. Solid State Physics, M. Ali Omar
3. Solid State Physics, A. J. Deckker
4. Introduction to Solid State Physics, Kittel
5. Solid State Physics, R. L. Singhal
6. Elements of Solid-State Physics, J. P. Srivastava
7. Solid State Physics Theory, Applications and Problems, S. L. Kakani & C. Hemraja
8. Solid State Physics, Ashcroft and Mermin.
9. X – Ray Spectroscopy – Teo
10. X-Ray Spectroscopy – A. Murari.
11. Physics of Semiconductor Devices, S. M. Sze, Wiley-Eastern Ltd (1981)
12. Solid state electronic devices, Ben G. Streetman, Prentice Hall, Englewood Cliffs. NJ (1999)
13. Semiconductor Devices, M. S. Tyagi, Wiley (India)
14. Electronic Devices, L. Floyd, Pearson Education New York (2004)
15. Transistors, Dennis Le Crissitte, Prentice Hall India Pvt. Ltd (1963)
16. Integrated Electronics, J. Milman and C. C. Halkias, McGraw Hill (1972)
17. Semiconductor Devices and Applications, A.Mottershed, New Age Int Pub.
18. Semiconductor Device Technology, M. Goodge, Mc Millan (1983)
19. Introduction to Solid State Physics: Arun Kumar PHI Learning
20. Basic Electronics: Arun Kumar, (Bharti Bhawan 2007)

PHY C- 11 (Nuclear and Particle Physics and Molecular Physics) (credit: 05, lectures: 60)

Nuclear and Particle Physics:

Unit-1

Nuclear Interactions: n-p & p-p scattering at low energy- General theory, Scattering Cross-Section, Scattering length, Effective Range theory, Meson theory of Nuclear Force, Yukawa interaction, Nature of the nuclear force, form of nucleon-nucleon potential, Charge independence and Charge symmetry of Nuclear forces, Spin-dependence of Nuclear forces, Coherent and Non-coherent Scattering, Isospin formalism. **[Lectures 12]**

Unit-2

Nuclear reaction: Resonance scattering, Breit Wigner one level formula, Bohr-Wheeler theory of Fission. Compound Nucleus theory, Ghosal Experiment **[10 Lectures]**

Unit-3

Nuclear Decay: (a) Beta Decay, Shape of the beta spectrum, Fermi's theory of Beta-decay, Parity violation and experimental verification.(b)Theory of Gamma Decay, Internal Conversion **[Lectures 20]**

Unit-4

Elementary Particle Physics: Types of interaction between elementary particles, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Hadrons and Leptons, Symmetry and Conservation Laws, elementary idea of CP and CPT invariance, baryons and mesons. Classification of Hadrons, Lie algebra, SU(2), SU(3), Quark model, Gell-Mann Nishijima formula for Octal and Decuplet Hadrons, Charm, Bottom and Top Quarks, Parity non- conservation in weak interaction. **[Lectures 18]**

Molecular Physics (Quantum Approach):

Unit-5

Rotational and Vibration spectra for diatomic molecules, Born-Oppenheimer approximation. Electronic spectra of diatomic molecules, Vibrational analysis of band system, Frank Condon

principle, Infrared spectra and Raman spectra of diatomic molecules. selection rules. Electron Spin Resonance (ESR) , and Nuclear Magnetic Resonance (NMR) chemical shift**. [Lectures 10]**

Reference Books:

1. Nuclear Physics, D. C. Tayal
2. Nuclear Physics, S. N. Ghoshal
3. Nuclear Physics, I. Kaplan
4. Nuclear Physics, Roy and Nigam
5. Introduction to Nuclear Physics, S. B. Patel
6. Introduction to Particle Physics, M. P. Khanna
7. Elementary Particle Physics, D. J. Griffiths

PHY C/P- 12 (CMP Practical) (credit: 05, lectures: 60)

1. Determination of Magnetic field strength and Resonance frequency using E. S. R.
2. Determination of Operating voltage of G. M. Counter
3. Determination of Energy Band Gap using Four Probe method
4. Determination of Hall coefficient and Hall angle in Hall-effect
5. Determination of Planck's constant
6. Measurement of Dielectric constants of solid and liquid samples
7. Determination of Curie temperature
8. Study of Hysteresis loss in given sample
9. Free running Multivibrator
10. Determining Optical constants of a metal by reflection of light
11. Lattice dynamics

Semester – IV

PHY E - 13 (Electronics Special-I) (credit: 05, lectures: 60)

Unit-1

Operational Amplifier: Differential Amplifier – Circuit Configuration, Dual Input, Balanced Output Differential Amplifier, DC and AC analysis, Inverting and Non – Inverting Inputs, CMRR, Constant Current, Bias Level Translator. Block Diagram of an Operational Amplifier. Open Loop Configuration. Inverting and Non – Inverting amplifiers. Op – amp with negative feedback. Voltage Follower. Input bias current, Input Offset current, Total output offset voltage, Adder, Subtractor, Differentiator and Integrator**. [Lectures 15]**

Unit-2

Oscillators: Oscillators Principles – Types, Frequency, Stability Response. The Phase shift Oscillators. Wein Bridge Oscillator Ble Oscillators. Multivibrators – Monostable, astable and Bistable. Comparators, Square wave and Triangular Wave Generators**. [Using Op – Amp only**] [Lectures 10]

Unit-3

Communication Electronics: DSBSC Modulation, Generation of DSBSC waves, Coherent detection of DSBSC waves, SSB Modulation, Generation and Detection of SSB waves.Vestigal side band Modulator, Frequency Modulation and Detection, PCM, Frequency Division Multiplexing (FDM**).[Lectures 10]**

Unit-4

Memory Devices : ROM , RAM and its applications, SRAM, DRAM, CMOS, NMOS, Non Volatile magnetic, Optical and Ferroelectric Memories, charge Coupled Devices.[**Lectures 5]**

Unit-5

Microwave Devices: Velocity Modulation, Two – Cavity Klystrons and Reflex Klystrons, Magnetrons, Travelling Wave Tubes, Wave Modes**.[Lectures 8]**

Unit-6

Microprocessors: Introduction to Microprocessors, Microcontrollers and Microcomputers, Architecture and Internal operation of INTEL 8085. Instruction OP codes. Operands and Mnemonic Constructing Machine Language code for Instructions , Instructions Execution Timing Diagram, Instruction Word Size and Addressing Modes, Instruction Set, Stacks, Subroutines and Interrupts. Machine and Assembly Language Programming**. [Lectures 12]**

Reference Books:

1. A handbook of Electronics – Gupta and Kumar.
2. Advanced Electronic Communication System – Wayne Tomasi.
3. Digital Principles and Applications – A.P. Malvino and Donald P. Leach.
4. Microprocessor Architecture, Programming and Applications with 8085/8086 – Ramesh S. Gaonkar.
5. Gayakwad, “Op-Amps and Linear Integrated Circuits”,3/e, Prentice-Hall of India
6. Sedra & Smith, “Microelectronic Circuits”, 3/e, Sounders College Publishing.
7. Microwave and Radar Engineering: Kulkarni, Umesh Publication
8. Electronic Communication Systems: Kennedy & Davis, TMH

PHY E- 14 (Electronics Special-II) (credit: 05, lectures: 60)

Unit-1

Radar: Basic arrangement of radar system, Azimuth and range measurement, Operating characteristics of a radar system, Derivation of radar range equation. [5 Lectures]

Antenna: Antenna action, Short electric doublet, Linear array of n isotropic sources of equal amplitude and spacing, Broad-side array, Ordinary end-fire array, End fire array with increased directivity, Beam width of the main load, Yagi antenna, Resonant and non-resonant array. Arrangement **[8 lectures]**

Unit-2

Satellite Communications: Introducing Satellite Orbits and Geostationary Satellites, Look Angles, Satellite Classifications, spacing and Frequency allocation, Satellite Link Models – Up Link , Down Link, Cross Link Models, satellite Link Equations. CDMA and GSM mobile Transmission,CDMA TDMA FDMA Multiplexing Processes [**Lectures 8]**

Unit-3

Microwave Communications : Advantages of microwave Transmission, Path of long distance and short distance Microwave Communications Loss in Free Space, Atmospheric Effects on Propagation, Flat and Curved earth effect, Skip Distance Fading Sources. Ionospheres and Troposphere Layers and its effect in Microwave Communications **[Lectures 7]**

Unit – 4

Transmission line: Types of transmission line, distributed parameters, voltage and current relations on a radio frequency transmission line with respect to sending and receiving ends, propagation constant (□), attenuation constant (□) and phase constant (□), expressions for □ and
□, transmission line distortion and attenuation, conditions for no distortion, low distortion and low loss, line termination across a short circuit, open circuit pure resistance and complex impedance, quarter- wave and half-wave lines and their impedance matching properties**. [14 Lectures]**

Unit-5

Wave-guide: Field expressions for propagating TE and TM waves in hollow circular cylindrical wave-guides, impossibility of TEM waves in hollow wave guide, Attenuation in wave guides and Q-factor. **[8 Lectures]**

Unit- 6

Fiber optic communication: Principles of light transmission in a fiber, Light sources for fiber optic communication, Effect of index profile on propagation, Modes of propagation, Number of modes a fiber may support, Single mode fiber, Losses in fibers. **[10 Lectures]**

Reference Books:

1. A handbook of Electronics – Gupta and Kumar.
2. Advanced Electronic Communication System – Wayne Tomasi.
3. Gayakwad, "Op-Amps and Linear Integrated Circuits",3/e, Prentice-Hall of India
4. Sedra & Smith, "Microelectronic Circuits", 3/e, Sounders College Publishing.
5. Microwave and Radar Engineering: Kulkarni, Umesh Publication
6. Electronic Communication Systems: Kennedy & Davis, TMH

PHY E – 15/P [Special Electronics Practical] (credit: 05, lectures: 60)

1. Study of Converters- A to D and D to A
2. Study of waveform of Monostable Multivibrator using Oscilloscope
3. Study of waveform of Bistable multivibrator using Oscilloscope
4. Study of Pulse Amplitude Modulation & Demodulation
5. Study of BCD to seven segments
6. Addition, Subtraction, Multiplication using 8085/8086
7. Optical Fiber- Measurement of loss in dB of patch cords
8. Study of Active filters
9. Waveform generation & Storage Amplifier
10. Network Analysis- Thevenin's & Norton's theorem.
11. Op – Amplifier – Differentiator & Integrator.
12. Logarithmic Amplifier.

Semester – IV

PHY E - 13 (Condensed Matter Physics (CMP) Special-I) (credit: 05, lectures: 60)

Unit-1:

Lattice Dynamics and Optical Properties of Solids: Vibration of crystals with monatomic basis, dispersion, Brillouin zones, phase and group velocities. Vibration (one dimensional) of crystals with diatomic basis, dispersion, Brillouin zones, acoustic and optical modes of vibration, frequency gap and effect of mass ratio on it, Reststrahlen, quantization of elastic waves, phonons, vibration in three-dimensional lattice, phonon density and states Van Hove singularities, coupled oscillators, scattering of neutrons by phonons.

Unit-2:

Interaction of solid with e.m. field: Drude model, macroscopic theory of optical constants, dispersion and absorption, dispersion formula. Dielectrics, Plasmons, Polarons and Polaritons: Macroscopic dielectric constant, Mechanism of polarization, electronic polarizability, ionic polarizability, molecular field in a dielectric, Clausius-Mossotti equation, frequency dependence of different polarizabilities, dielectric constant and alternating fields, Clausius-Mossotti catastrophe, permanent polarization and ferroelectricity, classification of ferroelectric crystals, their properties and applications, plasma oscillations and plasmons, experimental setup for plasma excitation, ionic polarization, long wavelength limiting frequency of optical modes in crystals, Interaction of
e.m. waves with optical modes (polaritons), electron-phonon interaction in ionic crystals (polarons).

Unit-3

Magnetic properties of solids: Quantum theories of diamagnetism, paramagnetic and ferromagnetism, Curie point and Neel temperature, Weiss Molecular field theory, Heisenberg's exchange, Interaction in ferromagnets, non-integral values of magnetization in Fe, Co and Ni, antiferromagnetism, ferrimagnetism, direct exchange and super exchange, spin waves and magnons, ferrites, their properties and applications, soft and hard magnetic materials.

PHY E- 14 (Condensed Matter Physics (CMP) Special-II) (credit: 05, lectures: 60)

Unit-1

Electronic Properties of Solids: Nearly free electron model and energy bands in one dimension, Tight-binding approximation, Wigner-Seitz cellular method, orthogonalized plane wave method, pseudopotential method, Fermi surface and its experimental determination: Magnetoresistance, cyclotron resonance, de Haas- Van Alphen effect, magneto-acoustic effect, quantum Hall effect, quantum wells and superlattices.

Unit-2

Crystal Imperfection: Importance and types of imperfections, point defects, vacancy defects in elemental solids, Schottky defect in ionic crystals, self interstitial defect in elemental solids, colour or F-centres, excitons, Dislocations, edge and screw dislocations, interpretation of slip, dislocation identity, estimation of dislocation density from X-ray diffraction measurements, energies of dislocations, stability of a dislocation loop, critical radius, role of dislocation in crystal growth and plastic deformation, solid solutions.

Unit-3

Superconductivity: manifestations of energy gap, Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg-Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect, Macroscopic quantum interference, Vortices and type II superconductors, high temperature superconductivity (elementary). Flux quantization, properties of high T_c superconductors, Cuprate superconductors and their theories, SQUID MAGLEV and principle of high speed trains, superconducting magnets.

Reference Books:

1. Ashcroft & Mermin, Solid State Physics.
2. C. Kittel, Introduction to Solid State Physics.
3. C.Kittel, Quantum Theory of Solids.
4. A. J. Dekker, Solid State Physics.
5. M. Ali Omar, Elementary Solid State Physics.
6. J.P. Srivastava, Elements of Solid State Physics.
7. J. Callaway, Quantum Theory of Solids.

PHY E – 15/P [Special Condensed Matter Physics (CMP) Practical] (credit: 05, lectures: 60)

1. Measurement of resistance of a semiconductor by four probe method at different temperatures and determination of band gap.
2. (i) Measurement of hall coefficient of given semiconductor.
   (ii) Identification of semiconductor and estimation of charge carrier concentration.
3. Determination of Planck's constant.
4. Determination of Lande's g-factor using ESR spectrometer.
5. Determination of Dielectric constants of Solids and Liquids.
6. Studies in Superconductivity- (i) Meissner Effect, (ii) Critical Field.

PHY D – 16 [Dissertation] (credit: 05, lectures: 60)

Full Marks: 100

This course will be based on preliminary research oriented topics both in theory and experiments. The teachers who will act as supervisors for the project will float projects and any one of them will be allocated to the student at the end of semester-II. At the completion of the project by the semester end the student will submit Project Report in the form of dissertation which will be examined by the examiners. The examination shall consist of

(a) Presentation and (b) Comprehensive viva-voce.

The examiners of the project report will comprise one external and one internal/Project supervisor. The distribution of marks for the project work will be as follows.

(a) Dissertation- 50 Marks
(b) Presentation- 25 marks
(c) Viva-voce examination- 25 marks

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