INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-101** Course Title: **Introduction to Engineering Physics**

2. Contact Hours: **L: 2** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 2** **Practical: 0**

4. Relative Weight**: CWS: 0** **PRS: 0** **MTE: 0** **ETE: 100** **PRE: 0**

5. Credits**: 2** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce basic concepts of Engineering Physics and various specializations in Physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Engineering physics, need for Physics in various streams of engineering, role of Physics in multidisciplinary and upcoming areas	**2**
2.	Introduction to various disciplines in Physics: Atomic Molecular and Laser Physics, basics of atomic physics and its engineering applications, basics of lasers and their industrial and engineering, and medical applications, introduction to optoelectronics and photonics	**5**
3.	Introduction to condensed matter physics and its engineering applications, basics of nanotechnology and its applications in medicine, defense and space	**4**
4.	Introduction to collider physics, nuclear science and engineering, and, its applications in power generation, food, health and agriculture	**4**
5.	Basic concepts of atmospheric and space physics and its applications in weather forecasting and satellite communication	**3**
6.	Role of physics in electronics, telecommunication and software engineering	**2**
7.	Lab tours of various teaching and research laboratories and demonstration of various instruments and experiments	**8**
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hecht J and Teresi D, “Laser: Light of a Million Uses,” Dover Publications	1998
2.	Ghatak A and Thyagarajan K, “Fiber Optics and Lasers : The Two Revolutions,” Macmillan	2006
3.	Shultis J K and Faw R E, “Fundamentals of Nuclear Science and Engineering,” Marcel Dekker	2002
4.	Pradeep T, “Nano: The Essentials,” Mc Graw Hill	2008
5.	Hargreaves J K, "The solar-terrestrial environment", Cambridge University Press	2003
6.	Penrose R and Gardner M, “The Emperor's New Mind” Oxford University Press	2002
7.	Penrose R, “Shadows of the Mind: A Search for the Missing Science of Consciousness”, Oxford University Press	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE : **DEPARTMENT OF PHYSICS**

1. Subject Code**: PHN-103** Course Title**: Computer Programming**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester: **Autumn** 7. Subject Area**: ESC**

8. Pre-requisite**: None**

9. Objective: This course provides students with an entry-level foundation in computer programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to computer hardware and software, information storage in computer memory, stored program concept, storage media, computer operating system	**4**
2.	Basic concept of FORTRAN/C language and program organization, arithmetic expressions, numerical input/output statement, loop instructions, transfer of control through logical statements, arrays and subscripted variables, standard I/O in "Fortran language", fundamental data types and storage classes: character types, integer, short, long, unsigned, single and double-precision floating point, storage classes, automatic, register, static and external, operators and expressions: using numeric and relational operators, mixed operands and type conversion, logical operators, bit operations, operator precedence and associativity	**6**
3.	Use of functions, subroutines, complex numbers, *COMMON* statement, block data, developing and testing of computer programs for various numerical problems	**8**
4.	Conditional program execution: applying *IF* and *SWITCH* statements, nesting *IF* and *ELSE*, restrictions on switch values, use of *BREAK* and *DEFAULT* with *SWITCH*, program loops and iteration: uses of *WHILE*, *DO* and *FOR* loops, multiple loop variables, assignment operators, using *BREAK* and *CONTINUE*	**8**
5.	Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size, structures: purpose and usage of structures, declaring structures, assigning of structures	**6**

6.	Solution of linear and quadratic equations, matrix addition, subtraction and multiplication, trace and norm of matrix, inverse of matrix, numerical interpolation, differentiation and integration (Simpson, Trapezoidal and Gauss' Quadrature methods)	**10**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Metcalf M, Reid J and Cohen M, Modern, "Fortran Explained (Numerical Mathematics and Scientific Computation)" Oxford University Press, USA, 4th edition	2011
2.	Clerman N S and Spector W, "Modern Fortran: Style and Usage", Cambridge University Press	2011
3.	Hoffmann J D, "Numerical Methods for Engineers and Scientists", Marcel Dekker Inc. 2nd edition	2001
4.	Sastry S S, "Introductory Methods of Numerical Analysis", PHI Learning, 5th edition	2012
5.	Smolarski D C, "The essentials of FORTRAN", Research and Education Association, USA	1989
6.	Lipschutz S and Poe A, "Theory and problems of Programming with Fortran", Schaum's Series Publications	1982
7.	McCormick J M and Salvodori M G, "Numerical methods in Fortran" Prentice Hall Publications	1964

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code**: PHN-008** Course Title**: Electromagnetic Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce basic concepts of electromagnetism and their applications in engineering.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Vector Calculus:** Review of cartesian, cylindrical and spherical coordinate systems, constant coordinate surfaces, del operator, gradient, divergence of a vector and Gauss divergence theorem, curl of a vector and Stokes theorem, gradient, divergence, curl and Laplacian in the three coordinate systems, Laplacian of a scalar, scalar & vector fields, classification of vector fields	**6**
2.	**Electrostatics:** Coulomb's law, electric field intensity due to continuous charge distribution, Gauss's law and its applications, electric potential, line integral, electric dipole and flux lines, energy density in an electrostatic field, metallic conductors, conductor properties and boundary conditions, polarization in dielectrics, nature of dielectric materials and related boundary conditions, electrostatic boundary-value problems, Laplace's and Poisson's equations, uniqueness theorem, general procedure for solving Laplace's and Poisson's equation in one-dimension, resistance and capacitance	**12**
3.	**Magnetostatics:** current, current density, Biot-Savart's law, Ampere's circuital law, applications of Ampere's law, magnetic flux and magnetic flux density, scalar and vector magnetic potentials, magnetic dipole, force due to magnetic field on a differential current element, force between two differential current elements, force and torque on a closed circuit, magnetic materials, magnetization and permeability, magnetic boundary conditions, inductors, inductances, magnetic energy, magnetic circuits, potential energy and force on magnetic materials	**12**

4.	**Time varying electric and magnetic fields, Electromagnetic waves:** Faraday's law, displacement current, Maxwell's equations for time varying fields, electromagnetic wave equation in free space, plane waves in free space, polarization, Poynting vector and power associated with electromagnetic waves, plane waves in lossless, homogeneous, and isotropic dielectric medium, reflection and transmission of plane waves at dielectric interface, normal and oblique incidence, plane waves in good conductors, skin depth	**12**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Sadiku M N O, "Elements of Engineering Electromagnetics" , Oxford University Press, 3rd Ed.	**2003**
2.	Griffiths D J, "Introduction to Electrodynamics", Prentice Hall, 3rd Ed.	**2000**
3.	Hayt W H Jr and Buck J A, "Engineering Electromagnetics", Tata McGraw Hill Publishing Company Ltd, New Delhi, 7th Ed.	**2005**
4.	Purcell E, "Electricity and Magnetism", Berkeley Physics Course, volume 2	**2011**
5.	Jackson J D, "Classical Electrodynamics" John Wiley & Sons; 3rd Ed.	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN- 102** Course Title: **Analog and Digital Electronics**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 2**

4. Relative Weight**: CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce basic concepts of electronics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductor Diode:** Energy band structure of Insulators, Semiconductors and Metals, Element and Compound semiconductors, Intrinsic semiconductors, Extrinsic semiconductors, electrons and holes, carrier concentration and their temperature dependence, Qualitative theory of the p-n junction, Barrier formation in p-n Junction Diode, current flow mechanism in Forward and Reverse Biased Diode, Volt-Ampere characteristics, Static and Dynamic Resistance of Diode, Zener Diode	**7**
2.	**Bipolar Junction transistors:** n-p-n and p-n-p transistors, Characteristics of CB, CE and CC configurations, Current gains α, β and γ and relations between them, Active, Cutoff, and Saturation regions, biasing of transistors: base bias, emitter bias, voltage divider bias, Emitter follower circuit, load line analysis	**7**
3.	**Amplifiers & Oscillators:** Analysis of a single-stage CE amplifier using DC Load Line, Coupled Amplifiers: RC-Coupled Amplifier and its Frequency Response of Voltage Gain, Operational Amplifiers: Inverting and non-inverting Amplifiers, feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance and Gain, Stability, Distortion and Noise, Sinusoidal Oscillators: Barkhauson's Criterion for self-sustained oscillations, RC Phase Shift Oscillator, Determination of frequency, Non-Sinusoidal Oscillators– Multivibrators	**8**

4.	**Field Effect Transistors**: Junction Field Effect Transistors, Pinch-Off Voltage, Volt-Ampere Characteristics of JFET, Insulated -Gate FET (MOSFET), Enhancement MOSFET, Depletion MOSFET, Circuit symbols	**5**
5.	**Digital Circuits:** Difference Between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, Binary codes, AND, OR and NOT Gates), NAND AND NOR Gates. Exclusive OR and Exclusive NOR Gates, Half and full adders, Encoders, Decoder and multiplexer circuits	**7**
6.	Basic concepts of flip-flops, Flip flops: RS, J-K, D and T flip flops; Counters, Registers; Clocks and Timers, A/D and D/A converters. Realization of basic logic gates using Diodes and Transistors, Transistor-transistor logic (TTL) and CMOS logics	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Streetman B G and Banerjee S, "Solid State Electronic Devices", Prentice Hall, 6th Ed.	**2006**
2.	Boylestad R L and Nashelsky L, "Electronic Devices and Circuit Theory", Pearson Education, 8th Ed.	**2004**
3.	Malvino A P, "Electronic Principles", McGraw Hill Publication, 7th Ed.	**2006**
4.	Malvino A P and Leach D P, "Digital Principles and Applications", MacGraw Hill Publication	**1998**
5.	Dedra A S and Smith K C, " Microelectronic Circuits: Theory and Applications" Oxford University Press, 6th Ed.	**2013**
6.	Millman J and Halkias C C, "Integrated Electronics", Tata McGraw Hill	**1995**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **DEPARTMENT OF PHYSICS**

1. Subject Code**: PHN-207** Course Title**: Thermal and Statistical Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 2**

4. Relative Weight**: CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: The course aims at familiarizing students with laws of thermodynamics and their correspondence with statistical mechanics.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Concept of pressure and radiation thermometry and absolute temperature, Internal energy function, Heat capacity, Hydrostatic system, Extensive and intensive parameters, Conduction, Convection, Radiation of heat, Kirchhoff's law of radiated heat and Stefan-Boltzmann law	5
2.	Equation of state of ideal and real gas, Quasi-static, adiabatic process, Microscopic point of view, Irreversible part of the second law, Heat and entropy in irreversible and reversible processes, Entropy and Non equilibrium states, Application of the entropy principle	5
3.	Phase Diagram of pure substance: PV, PT, TS diagram, Volume expansivity, compressibility, Molar heat capacities and its measurement, Drawback of equipartition theorem	5
4.	Enthalpy, Helmholtz & Gibb's functions, Maxwell's thermodynamic relations, Heat capacity equation, Chemical potential, Criteria for 1^{st} and 2^{nd} -order Phase transitions and their study of in terms of thermodynamic potentials/free energies	5
5.	Free expansion of a gas, Throttling process and inversion curve**,** Liquefaction of gases, Magnetic cooling, Phase behavior of Helium	5
6.	Phase space and definition of microstates, Liouville's theorem and its consequences, a priori equal probability, Microcanonical ensemble, Contact between statistics and thermodynamics	7

7.	Isolated system and its contact with a heat reservoir, Canonical ensemble, Calculation of thermodynamic quantities for an ideal monatomic gas and Gibbs paradox	5
8.	Identical particles and symmetry requirements, M-B, B-E and F-D statistics and the corresponding distribution functions , Blackbody spectrum	5
	Total	42

Laboratory work related to the course:

I	Measurement of temperature using thermister
II	Specific heat measurements
III	Stefan's constant and work function of a photo cathode using incandescent lamp
IV	Thermal conductivity of metal by Searle's apparatus.
V	Verification of Stefan's law
VI	J by Callendar and Barn's method
VII	Temperature coefficient of resistance by Callendar and Griffiths bridge
VIII	Thermal conductivity of Glass (Tube form)
IX	Co-efficient of thermal expansion
X	Thermo-emf by Potentiometer
XI	Thermal equation of state and critical point

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Reif F, "Fundamentals of Statistical and Thermal Physics", McGraw Hill	1965
2.	Zemansky M W and Dittman R H, "Heat & Thermodynamics" , McGraw Hill	1997
3.	Sears F W and Salinger G L, "Thermodynamics, Kinetic Theory & Statistical Thermodynamics" Narosa Publishers	1998
4.	Huang K, "Statistical Mechanics", John Wiley	1987
5.	Guha E, "Basic Thermodynamics", Narosa Publishers	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-205** Course Title: **Engineering Analysis and Design**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 2** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: This course will introduce the students to analysis and design of various physical systems using software packages.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Need for simulation in physics problems. Logical and physical design, Design representation, Systems, flowcharts and structured charts, Data flow diagrams	3
2.	**System Models:** System environment, Stochastic Activities, Continuous and Discrete Systems, Static and dynamic Physical Models, Static and Dynamic Mathematical Models, Principles used in Modeling	3
3.	**System Studies:** Subsystems, Types of System Study, System Analysis, System Design, System Postulation	2
4.	**System Simulation:** Technique of Simulation, Mote Carlo Method, Comparison of Simulation and Analytical Methods, Experimental Nature of Simulations, Numerical Computational Technique for continuous and Discrete Models	3
5.	**Simulation Software:** Matlab/Mathematica, Saving and Loading Data, Programming a Function, Loops, Branches and Control Flow, Input/Output, 2-D and 3-D Plots	5
6.	**Simulation of Problems in Mechanics:** 1-D Simple Harmonic Oscillator, Projectile Motion, Motion of a Satellite	4
7.	**Simulation of Problems in Waves and Optics:** Plane wave propagation, Standing Wave, Superposition of Harmonic Waves, Young's Double slit Experiment	4
8.	**Simulation of Problems in Electricity and Magnetism:** electric field of a point charge, of n-point charges, charged particle in electric and magnetic fields, electrical circuits	4
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Gordon G, “System Simulation”, Pearson Education	2009
2.	Pratap R, “Getting Started with Matlab 7”, Oxford University Press	2006
3.	“Mathematica Tutorial Collection”, Wolfram Mathematica	2008
4.	Gilat A, “Matlab: An Intodtuction with Applications”, Wiley India	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-207** Course Title: **Mechanics and Relativity**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To familiarize the students with the fundamentals of Mechanics and Special Theory of Relativity.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**KINEMATICS OF PARTICLES:** Curvilinear motion, relative velocity and acceleration, Newton's laws and applications (to include sliding- , belt- , wedge- friction and rolling resistance)	4
2.	**KINETICS OF PARTICLES :** Conservative forces, Potential, Work-Energy theorems, Energy-diagrams, Conservation of linear and angular momentum, Fixed axis rotation, Collisions, Variable mass problems	8
3.	**LAGRANGIAN MECHANICS:** Constraints, Principle of virtual work, Generalized coordinates, Lagrange's equation, Hamilton's equation	7
4.	**CENTRAL FORCES:** Gravitation, Kepler's law, hyperbolic, elliptic and parabolic orbits, Scattering theory, Center of mass and laboratory frames of reference	6
5.	**RIGID BODY MOTION:** Translation and rotation of rigid bodies- derivative of a vector fixed in moving reference- general relationship between time derivative of a vector for different references, moment of momentum equations- kinetic energy of rigid body, work and energy relations, Euler's equations of motion, gyroscope motion	10
6.	**SPECIAL THEORY OF RELATIVITY:** Michelson-Morley experiment, Galilean transformation, Length contraction, Time dilation, Lorentz transformations, Simultaneity, Relativistic addition of velocities, Doppler Effect, Equivalence of mass and energy	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Kleppner D and Kolenkow Robert, "An Introduction to Mechanics", Cambridge University Press	2013
2.	Spiegel M R, "Theory and Problems of Theoretical Physics", McGraw Hill	1968
3.	Rana N and Joag P, "Classical Mechanics", McGraw Hill	2001
4.	Goldstein H, "Classical Mechanics", Narosa Publications	2001
5.	Resnick R, "Introduction to Special Relativity", Wiley Publications	2007
6.	Beiser A, "Concepts of Modern Physics", McGraw Hill, 6^{th} Ed.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-209** Course Title: **Mathematical Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To familiarize students with standard techniques in Mathematical Physics.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Vectors and Tensors:** Applications of Gauss's and Stokes' theorem; Orthogonal curvilinear coordinate systems, Covariant and Contravariant tensors, covariant derivatives, Christoffel symbols, Curvature tensor	**8**
2.	**Complex variables and applications:** analytic functions, residue calculus, singularities, contour integration, conformal mapping and its applications, Fourier series, Fourier and Laplace transforms, evaluation of integral transforms and their inverses using contour integrals	**10**
3.	**Elements of linear algebra:** Vector space, Orthogonal bases Eigenvalues and eigenvectors, Diagonalisation techniques, Gramm-Schmidt orthogonalization, Similarity transformations	**6**
4.	**Special functions and boundary value problems:** Solutions of Legendre-and associated Legendre-; Hermite-; Laguerre-and associated Laguerre-; Bessel's- and Hypergeometric equations; Beta and gamma functions; Laplace's equation and its solutions in different dimensions; The Riemann-P symbol approach to 2^{nd} order differential equations in the complex plane	**12**
5.	**Green's function techniques**: Green's functions and solutions of inhomogeneous differential equations and applications	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Arfken G B and Weber H J, “Mathematical Methods for Physicists” , 5th Ed. Academic Press.	2005
2.	Whittaker E T and Watson E W, “A Course of Modern Analysis”, Cambridge University Press	2008
3.	Shankar R, “Basic Training in Mathematics: A Fitness Program for Science Students”, Springer	1995
4.	Kreyszig E, “Advanced Engineering Mathematics”, 9th Ed. Wiley India Pvt. Ltd.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-211** Course Title: **Quantum Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 03** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce the basic concepts of quantum mechanics and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Prelude to Quantum Mechanics:** Failures of classical physics; diffraction of matter particles, de Broglie waves and Davisson-Germer Experiment, Wave-particle duality, Bohr atom model	**04**
2.	**Elements of Quantum Mechanics:** Schrodinger equation, interpretation of the wavefunction, wave packets, stationary states; Heisenberg Uncertainty principle, Basic postulates and meaning of the measurement, Observables and operators	**08**
3.	**Problems in one-dimension:** Particle in a box, Potential step, Potential barrier: reflection and transmission coefficients; Potential well, Simple harmonic oscillator	**10**
4.	**Problems in three-dimension:** Central potential, Hydrogen atom, Angular Momentum and Spherical harmonics, Addition of Angular Momenta and Clebsch Gordon coefficients	**08**
5.	**Approximate Methods:** Basic idea of WKB approximation and its applications, basic ideas of time-dependent and time-independent perturbation methods and their applications	**06**
6.	**Scattering Theory:** Scattering amplitude, differential and total cross-section, scattering by a central potential, method of partial waves and the Born approximation	**06**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Beiser A, “Concepts of Modern Physics”, McGraw Hill, 6th Ed.	2009
2.	Eisberg R M, and Resnick R, “Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles” Wiley,	1985
3.	Gasiorowicz S, “Quantum Physics”, John Wiley	2003
4.	Liboff, R L, “Introductory Quantum Mechanics” Addison Wesley	2002
5.	Shankar R, “Principles of Quantum Mechanics”, Plenum Press	1994
6.	Griffiths D J, “Introduction to Quantum Mechanics”, Prentice Hall	1995
7.	Tyagi I S, “Principles of Quantum Mechanics”, Pearson Education	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-204** Course Title: **Atomic, Molecular and Laser Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 03** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 3** 6. Semester**: Spring** 7. Subject Area: **DCC**

8. Pre-requisite**:** **Nil**

9. Objective of Course**:** To introduce basic principles of Atomic and Molecular Spectroscopy and Lasers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atomic Spectroscopy-I:** Spectra of one- and two- electron systems, Alkali spectra, Electron spin and magnetic moment, electric-dipole allowed transition (E1) and selection rules, Fine structure splitting: spin-orbit interaction and relativistic corrections; Lamb shift, Hyperfine structure and isotope shifts	10
2.	**Atomic Spectroscopy-II:** Many-electron atoms, Pauli exclusion principle, Angular momentum coupling schemes: L-S and j-j coupling, equivalent and non-equivalent electrons, Hunds rules, ground state configurations of elements in periodic table; atoms in electric and magnetic fields (Zeeman effect, Paschen-Back effect and Stark effect), X-ray spectra	10
3.	**Molecular Structure:** Born-Oppenheimer Approximation, Homo and Hetero diatomic molecule, Role of a permanent dipole moment in diatomic molecule.	4
4.	**Molecular spectroscopy:** Rotational Spectroscopy: Rigid Rotator, Non-rigid rotator, Vibrating rotator. Vibrational Spectroscopy: Harmonic oscillator, Anharmonic oscillator, Vibrating rotator or rotating oscillator, dissociation energy of molecules. Raman Spectroscopy: Classical theory of light scattering and Raman effect, Quantum theory of the Raman effect, selection rules for Raman spectrum. Electronic Spectroscopy: Electronic energy and total energy of a molecule, Selection rules for electronic spectroscopy, Franck-Condon principle. Quantum numbers for molecular spectroscopy	14
5.	**Lasers:** Discussion on Spontaneous and Stimulated Emission, Absorption, population inversion, Brief discussion on three-level and four-level laser schemes, Properties of laser beams: Monochromaticity, spatial and temporal coherence, brightness, directionality. Intensity profile of laser beam, He-Ne laser	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Bransden B H and Joachian C J, “Physics of Atoms and Molecules” 2nd ed., Prentice Hall.	2012
2.	Haken H and Wolf H C, “The Physics of Atoms and Quanta”, 6th Ed., Springer.	2007
3.	Herzberg G, “Molecular Spectra and Molecular Structure: Spectra of Diatomic Molecules”, Dover Books on Physics.	2010
4.	Svelto O, “Principles of Lasers” 5th Ed, Springer	2010
5.	White H E, “Introduction to Atomic Spectra,” McGraw-Hill Inc.	1934

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-206** Course Title: **Elements of Condensed Matter Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To familiarize students with bonding, mechanical properties, crystal structure, lattice vibrations, defects in solids and theory of magnetism.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystal Structure:** Point symmetry, translational symmetry, two- and three- dimensional lattices, simple crystal structures, Miller indices, diffraction from periodic structures (X-ray, neutron), reciprocal lattice, Brillouin zones	**09**
2.	**Bonding:** Covalent bonding, ionic bonding and metallic bonding	**03**
3.	**Lattice vibrations:** One dimensional lattices (monoatomic and diatomic), quantization of elastic waves, phonon momentum, density of modes, Einstein and Debye theory of specific heat	**08**
4.	**Electrons in solids:** Free electron gas in metals (Drude and Sommerfeld models), periodic potential and Bloch's theorem, Kronig-Penney model, electrical and thermal conductivity, electronic specific heat	**08**
5.	**Magnetism:** Langevin theory of dia- and para- magnetism, quantum theory of dia- and para-magnetism, magnetic ordering, Weiss molecular field theory of ferromagnetism and antiferromagnetism, Hund's rules, NMR	**08**
6.	**Superconductivity:** Zero resistance**,** Meissner effect, critical fields and currents, Type-I and Type-II superconductors, energy gap, thermodynamics of superconductor	**06**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Kittel C, "Introduction to Solid State Physics", 8th Ed. Wiley Eastern Ltd.	2004
2.	Ashcroft N M and Mermin N D, "Solid State Physics", (2nd Ed.) Holt-Saunders	2004
3.	Hook J R and Hall H E, "Solid State Physics", John Wiley	2001
4.	Blundell S, "Magnetism in Condensed Matter", Oxford University press	2001
5.	Ibach H and Lueth H, "Solid State Physics", Springer	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-208** Course Title: **Nuclear Physics and Applications**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To familiarize students with the basic concepts of nuclear physics and its industrial, analytical, medicinal and energy applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Nuclear shape, size, radii, matter/charge distributions; Nuclear force; Concept of isospin; Charge independence of nuclear forces in the light of isospin. Mass defect and binding energy; Liquid drop model; Semi empirical mass formula; Evidence of shell structure; Shell model with harmonic oscillator and spin-orbit potential and its predictions	9
2.	α-decay, its properties, range, range-energy relationship, Geiger-Nuttal law, theory of α-decay, β-decay and its classifications (only basics), γ-decay: range, properties, pair production, energy spectra and nuclear energy levels	8
3.	Nuclear reaction, Kinematics, Direct nuclear reaction, Compound nuclear reaction, Nuclear fission and fusion	7
4.	Gas, Scintillation and Semiconductor detectors. Neutron detectors, Accelerators: Cyclotron and Linac	9
5.	Industrial, analytical and medicinal applications; Power from fission, Nuclear reactors; Source of stellar energy	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Lilley J S, “Nuclear Physics”, John Wiley & Sons	2001
2.	Ghoshal S N, “Nuclear Physics”, S. Chand & Comp. Ltd	2000
3.	Povh B, Rith K, Scholz C and Zetsch F, “ Particles and Nuclei”, 2nd Ed. Springer	1999
4.	Heyde K, “ From Nucleons to the Atomic Nucleus”, Springer	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-210** Course Title: **Microprocessors and Peripheral Devices**

2. Contact Hours: **L: 3** **T: 1** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 2**

4. Relative Weight**: CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 5** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To provide in-depth knowledge of the architecture, instruction set and programming of typical 8-bit microprocessor and programmable support chips.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction of Microcomputer System**: CPU, I/O devices, clock, memory, bussed architecture, tri-state logic, address bus, data bus and control bus	3
2.	**Semiconductor Memories**: MROM, ROM, EPROM, EEPROM, DRAM, internal structure and decoding, memory read and write timing diagrams	3
3.	**Intel 8085A microprocessor:** Pin description and internal architecture; Timing and control unit, op-code fetch machine cycle, memory read/write machine cycles, I/O read/write machine cycles, interrupt acknowledge machine cycle, state-transition diagram	8
4.	**Instruction Set:** Addressing modes; Data transfer, arithmetic, logical, branch, stack and machine control groups of instruction set, macro RTL and micro RTL flow chart of few typical instructions; Unspecified flags and instructions	7
5.	**Assembly Language Programming:** Assembler directives, simple examples; Subroutines, parameter passing to subroutines	5
6.	**Interfacing:** Interfacing of memory chips, address allocation technique and decoding; Interfacing of I/O devices, LEDs and toggle-switches as examples, memory mapped and isolated I/O structure; Input/Output techniques: CPU initiated unconditional and conditional I/O transfer, device initiated interrupt I/O transfer	5

7.	**Interrupts:** Interrupt structure of 8085A microprocessor, processing of vectored and non-vectored interrupts, latency time and response time	**3**
8.	**Programmable Peripheral Interface:** Intel 8255, pin configuration, internal structure of a port bit, modes of operation, bit SET/RESET feature, programming; ADC and DAC chips and their interfacing	**4**
9.	**Programmable Interval Timer:** Intel 8253, pin configuration, internal block diagram of counter, modes of operation, counter read methods, programming, READ-BACK command of Intel 8254	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Hall D V, "Microprocessor and Interfacing –Programming and Hardware", 2nd Ed., Tata McGraw-Hill Publishing Company Limited.	2008
2.	Gaonkar R S, "Microprocessor Architecture, Programming and Applications", 5th Ed., Penram International.	2007
3.	Stewart J, "Microprocessor Systems- Hardware, Software and Programming", Prentice Hall International Edition.	1990
4.	Short K L, "Microprocessors and Programmed Logic", 2nd Ed., Pearson Education.	2008
5.	Intel Manual on 8-bit Processors	
6.	Intel Manual on Peripheral Devices	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-214** Course Title: **Applied Optics**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 15 PRS: 25 MTE: 20 ETE: 40 PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce students to elements of optics i.e. interference, diffraction and polarization and their applications in engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Geometrical optics**: Fermat's principle, the ray equation and its solutions, matrix method in paraxial optics, unit planes, nodal planes, system of thin lenses	08
2.	**Interference:** Huygen's principle and its applications, interference by division of wavefront, two slit interference, Fresnel's Biprism, interference with white light, interference by division of amplitude, thin parallel films, wedge shaped films, Newton's rings, Michelson interferometer and its applications, multiple beam interference, Fabry Perot interferometer and etalon	10
3.	**Diffraction:** Fraunhofer diffraction, single, double and multiple slit diffraction, diffraction grating, diffraction at a circular aperture, Fresnel diffraction, Fresnel half period zones, the zone plate, diffraction at a straight edge, diffraction of a plane wave by a long narrow slit and transition to Fraunhofer region	10
4.	**Polarization:** Polarization and double refraction, production of polarized light, Brewster's law, Malus's law, double refraction, interference of polarized light, quarter and half wave plates, analysis of polarized light, optical activity	09
5.	**Applications:** Antireflection coatings, ellipsometry and applications of polarization based device, basics concepts of holography, basics concepts and ray optics considerations of optical fiber	05
	Total	**42**

List of experiments:

S. No.	Experiment	Contact hours
i.	Determination of wavelength of sodium light by Fresnel biprism.	
ii.	Determination of Young's modulus of a glass plate by Cornu's method.	
iii.	Determination of wavelength of laser light by Fabry Perot etalon.	
iv.	Normal dispersion curves and Cauchy's relations.	
v	Fresnel equations: rotation of plane of polarization by reflection.	
vi	Study of single, double and multiple slit diffractions.	
vii	Study of diffraction of light by a thin wire.	
viii	Determination of wavelength of light by Diffraction grating.	
ix	Production and analysis of polarized light using quarter wave plates.	
x	Nodal Slide Experiment	
xi	$\Delta\lambda$ by Michelson Interferometer	
xii	Thickness of Mica sheet by Michelson Interferometer	
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Ghatak A, "Optics" 4th Ed., Tata McGraw Hill	2009
2.	Hecht E, "Optics" 4th Ed., Addison Wesley	2001
3.	Jenkins F A and White H E, "Fundamentals of Optics" 3rd Ed., McGraw Hill	1976

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-311** Course Title: **Numerical Analysis and Computational Physics**

2. Contact Hours: **L: 2** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 02** **Practical: 03**

4. Relative Weight**: CWS:** 15 **PRS:** 25 **MTE:** 20 **ETE:** 40 **PRE:** 0

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: PHN-103 or equivalent**

9. Objective: To introduce numerical tools for computationally solving various problems of Engineering Physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**System of Linear Equations:** Exact methods: LU-decomposition, Gauss-elimination methods without and with partial pivoting, Iterative methods: Gauss-Jacobi and Gauss-Seidal methods, Matrix norm, Condition number and Ill-conditioning	**04**
2.	**Non-linear Equations and Roots of Polynomials:** Bisection method, Newton–Raphson's method, Direct Iterative method with convergence criterion	**04**
3.	**Numerical Interpolation and Curve Fitting:** Lagrange-, Hermite-, cubic spline interpolation methods and discussion on associated errors, Curve fitting by least squares	**05**
4.	**Numerical Calculus:** *Integral Calculus*:- General quadrature formula, Simpson's rules, Improper integrals, Gaussian quadrature formulae. *Differential Calculus*:- Numerical differentiation, Richardson Extrapolation	**07**
5.	**Ordinary Differential Equations:** Euler methods, Runge-Kutta methods and Numerov methods, second order differential equations, coupled differential equations, finite differences, eigen values via finite differences, the Power method and eigenvalue problem	**08**
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	DeVries P L, “A First Course in Computational Physics”, John Wiley	1994
2.	Landau R H, Paez M J and Bordeanu C C, “A Survey of Computational Physics”, Princeton University Press	2008
3.	Gerald C F and Wheatley O P, “Applied Numerical Analysis”, Addison Wesley; 7^{th} Ed.	2003
4.	Atkinson K E, “An Introduction to Numerical Analysis”, Wiley; 2^{nd} Ed.	1989
5.	Sastry S S, “Introductory Methods of Numerical Analysis”, Prentice Hall	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-313** Course Title: **Signals and Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To provide students an understanding of analysis and processing of signals in various systems including communication systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of communication, control and remote sensing systems, properties of systems, classifications of signals, basic operations on signals, elementary signals, exponential and sinusoidal, damped signals, step, impulse and ramp functions, systems as interconnections of operations, properties of systems	**6**
2.	Convolution, impulse response representation of linear time invariant (LTI) systems, convolution integral, step response	**6**
3.	Fourier representation of signals, periodic and non-periodic signals, Fourier series and Fourier transform, properties of Fourier representation, relationship between Fourier transform and Fourier series; Generalized Fourier transform; Amplitude and phase spectra, energy and power spectral density, signal bandwidth	**8**
4.	Laplace transform, relationship of Laplace and Fourier transforms, transfer function and its block diagram representation, convolution integral and the Fourier transfer function	**6**
5.	Review of z-transform and its properties, Discrete time Fourier transform and its properties; Discrete convolution and duality; Discrete Fourier transform and its properties; Computation of discrete time Fourier transform and discrete Fourier transform, approximation of Fourier transform and discrete convolution using discrete Fourier transform	**10**
5.	Applications to communication systems, sampling, modulation, multiplexing, phase and group delays	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Haykin S and Van Been B, “Signals and Systems” 2nd Ed., John Wiley & Sons	2003
2.	Lathi B P, “Linear Systems and Signals”, 2nd Ed., Oxford University Press	2006
3.	Oppenheim A V, Willsky A S and Nawab S H, “Signals & Systems”, 2nd Ed., Prentice-Hall of India	1997
4.	Roberts M J, “Fundamentals of Signals & Systems”, Tata McGraw-Hill	2007
5.	Ziemer R E, Tranter W H and Fannin D R, “Signals and systems: Continuous and Discrete”, 4th Ed., Pearson Education	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-315** Course Title: **Laser and Photonics**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce principles of different optoelectronics devices for science and engineering applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Light Matter Interaction:** Quantum theory for the evaluation of the transition rates and Einstein's coefficients, interaction of matter with radiation having broad spectrum, interaction of near monochromatic radiation with an atom having broad frequency response	6
2.	**Line Broadening:** Line broadening mechanisms, homogeneous and inhomogeneous broadening, natural collision and Doppler broadening mechanisms and line shape functions	3
3.	**Rate Equations:** Laser rate equations, two levels, three levels and four levels system, variation of power around threshold, optimum output coupling, quality factor, the ultimate line width of the laser	5
4.	**Laser Resonators:** Optical resonators, modes of a rectangular cavity and open planar resonators, confocal resonator system, modes of a confocal resonator using Huygen's principle, planar resonators	6
5.	**Transient Effects:** Pulsed lasers, Q-switching techniques, active and passive shutters, mode-locking, various techniques for mode-locking of a laser	4
6.	**Lasers Systems:** Mechanism and applications of Ar-ion, CO_2, Nd:YAG, Ti:Sapphire, Dye, Excimer, Diode pumped Solid State Laser	4

7.	**Modulation techniques for laser light**: electro-optic and acousto-optic modulation, electro-optic effect, longitudinal and transverse modes, acousto-optic effect, Raman-Nath and Bragg diffraction	**5**
8.	**Nonlinear Optics:** Nonlinear optical media, nonlinear polarization and susceptibility, second harmonic generation, optical Kerr effect, self-phase modulation, self-focusing	**5**
9.	**Applications:** Applications of lasers in material processing and micro machining, medicine, communication and information technology, military	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Svelto O, "Principles of Lasers", Springer	2010
2.	Ghatak A K and Thyagarajan K, "Optical Electronics**"**, Cambridge University Press	2003
3.	Yariv A, "Quantum Electronics**",** John Wiley & Sons	1989
4.	Thyagarajan K and Ghatak A, "Lasers: Theory and Applications", Macmillan	1997
5.	Yariv A, "Optical Electronics", Oxford University Press	1997
6.	Laud B B, "Lasers and Nonlinear Optics**"**, Wiley Eastern Ltd.	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-317** Course Title: **Plasma Physics and Applications**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: PHN-008**

9. Objective: To introduce the basic principles of plasma physics and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Plasma Physics:** Formation of Plasma, Debye shielding, Plasma parameters, Criteria for Plasma, Earth's ionosphere and Magnetosphere, Laboratory Plasma	**5**
2.	**Single Particle Motions:** Motion of charged particles in uniform and non-uniform **E** and **B** fields, Magnetic mirrors and their applications, Adiabatic invariants.	**6**
3.	**Plasma as a Fluid:** Relation of Plasma Physics with ordinary Electromagnetics, The Fluid Equation of Motion, Fluid drifts perpendicular and parallel to **B**, Plasma Approximation	**6**
4.	**Waves in Plasma:** Representation of waves, Plasma oscillations, Electron plasma waves, ion waves, Validity of plasma approximation, Comparison of ion and electron waves	**8**
5.	**Diffusion**: Diffusion and mobility in weakly ionized gases, Decay of a Plasma by Diffusion, Steady state solution, recombination	**3**
6.	**Instability:** Plasma instabilities and turbulence ionosphere, Two stream instability, gravitational instability, Rayleigh-Taylor instability	**6**
7.	**Applications:** Effect of plasma instabilities on satellite communications, Plasma as an industrial tool, Plasma diagnostics, Laser produced plasma, Thermonuclear plasma, Fusion reactions, Tokamak reactor	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Chen F F, "Introduction to Plasma Physics", Plenum Press, New York.	**1990**
2.	Kelley Michael C, "The Earth's Ionosphere: Plasma Physics and Electrodynamics", Elsevier Inc.	**2009**
3.	John P I, "Plasma Science and the Creation of Wealth", Tata McGraw-Hill Publishing Company Ltd.	**2005**
4.	Davidson R C, "Physics of Non-Neutral Plasmas", Allied Publishers Pvt. Ltd.	**2001**
5.	Eliezer S and Eliger Y, "The Fourth State of Matter: An Introduction to Plasma Science", CRC Press	**2001**
6.	Paul M B, "Fundamentals of Plasma Physics", Cambridge University Press	**2004**
7.	Bittencourt J A, " Fundamentals of Plasma Physics", Springer	**2004**
8.	Lifshitz E M, Pitaevskii L P, Kosevich A M , Sykes J B and Franklin R N, "Physical Kinetics: Volume 10", Elsevier	**1981**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-310** Course Title: **Applied Instrumentation**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 15 PRS: 25 MTE: 20 ETE: 40 PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: None**

9. Objective: To introduce working principles and characteristics of transducers and analytical instruments commonly used for industrial applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basics of transducers, sensors and actuators; Active and passive transducers, generating and parametric transducers; Analog, digital and pulse outputs of sensors; Static and dynamic characteristics of transducer and transducer system	**5**
2.	**Measurement of Displacement and Strain:** Resistive, inductive and capacitive transducers for displacement; Wire, metal film and semiconductor strain gauges; Wheatstone-bridge circuit with one, two and four active elements, temperature compensation	**5**
3.	**Measurement of Speed and Torque:** Electro-magnetic and photo-electric tachometers; Torque shaft, strain-gauge, electromagnetic and radio type torque meters	**3**
4.	**Measurement of Force and Pressure:** Column, ring and cantilever-beam type load cells; Elastic elements for pressure sensing; Using displacement sensors and strain gauges with elastic elements	**4**
5.	**Measurement of Temperature:** Resistance temperature detector, NTC and PTC thermistors, Seebeck effect, thermocouple and thermopile	**3**
6.	**Measurement of moisture and humidity**: Area and mass flow meters, electromagnetic flow meters	**4**

7.	**Digital Electronic Instrumentation:** Digital counter-timer and frequency meter, time standards, digital voltmeter and multimeter, accuracy and resolution considerations, comparison with analog electronic instruments, Lock-in amplifier	**6**
8.	X-ray Diffractometer and Electron Microscopy, AFM, TEM, STM	**4**
9.	Differential thermal analysis and Differential Scanning Calorimetry, TGA	**4**
10.	Electron probe microanalysis (EPMA), XPS	**4**
	Total	**42**

Experiments based on different types of transducers –

1. Measurement of pressure, strain and torque using strain gauge.
2. Measurement of speed using Electromagnetic transducer.
3. Measurement of speed using photoelectric transducers and compass
4. Measurement of angular displacement using Potentiometer.
5. Experiment of Opto coupler using photoelectric transducers.
6. Measurement of displacement using LVDT.
7. Measurement using load cells.
8. Measurement using capacitive transducer.
9. Measurement using inductive transducer.
10. Measurement of Temperature using Temperature Sensors/RTD
11. Characteristics of Hall effect sensor.
12. Measuring change in resistance using LDR

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rangan C S, Sharma G R and Mani V S V, "Instrumentation Devices and Systems", 2nd Ed., Tata McGraw-Hill	2008
2.	Doebelin E O and Manik D N, "Measurement Systems", 5th Ed., Tata McGraw-Hill	2008
3.	Cooper W D and Helfrick A D, "Modern Electronic Instrumentation and Measurement Techniques", Pearson Education	2008
4.	Anand M M S, "Electronic Instruments and Instrumentation Technology", Pearson Education	2008
5.	Nakra B C and Chaudhry K K , " Instrumentation Measurements & Analysis" McGraw Hill	2002
6.	Sayer M and Mansingh A, "Measurement, Instrumentation & Experiment Design in Physics & Engineering", PHI	1999
7.	Villard H H and Merritt L A, "Instrumental Method of Analysis", CBS Publications & Distributors	1988
8.	Cullity B D and Stock S R, " Elements of X-ray diffraction", Pears, 3rd Ed.	2014
9.	Patranabis D, "Principles of Industrial Instrumentation", Tata McGraw Hill	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-312** Course Title: **Semiconductor Devices**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **PHN-102**

9. Objective: To introduce the physics of semiconductors, p-n junction, bipolar junction transistors, FET and MOSFET.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductors:** Energy bands, direct and indirect semiconductors, charge carriers, mobility, drift of carriers in field, Diamond and Zinc-Blende structure, bonds and bands in semiconductors, intrinsic and extrinsic semiconductors, law of mass action, Hall effect and cyclotron resonance in semiconductors	12
2.	**Optical Injection:** Carrier life time, direct and indirect recombination of electron and holes, steady state carrier generation, diffusion and drift of carriers, the continuity equation, steady state carrier injection, Haynes-Shockley experiment	8
3.	**Junctions:** Metal-Semiconductor contact: under equilibrium, and non-equilibrium conditions, the junction diode theory, tunnel diode, photodiode, LED, solar cell, Hetro-junctions and Laser diode	10
4.	**Bipolar Junction Transistors:** Charge transport and amplification, minority carrier distribution and terminal currents switching behaviour in bipolar transistor	4
5.	**FET and MOSFET:** Ideal MOS capacitor, effect of work function and interface charge on threshold voltage	6
6.	**Gunn Diode:** Transferred electron mechanism and drift of space charge domain	2
	Total	**42**

List of Experiments:

S. No.	Experiment	Contact Hours
1.	To draw the I-V characteristics of a p-n junction diode in forward and reverse bias and to determine its DC and AC resistance for a given current.	
2.	To study the temperature dependence of the reverse saturation current of a p-n junction diode and to determine the band gap of semiconductor.	
3.	To study half wave, full wave and bridge rectifiers and to determine ripple factor.	
4.	To design a regulated power supply using Zener diode and fixed voltage regulator.	
5.	(a)To draw input and output characteristic of a bipolar transistor. (b)To design a CE amplifier and study its frequency response.	
6.	To draw input and output characteristic of a JFET and determine g_m, r_d and verify square law.	
7.	To design inverting and non-inverting amplifiers of different gain using operational amplifier and study their frequency response.	
8.	To verify truth tables of various logic gates.	
9.	To verify Boolean theorems using logic gates	
10.	To design and study of astable, monostable multivibrators using Timer 555	
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Streetman B G and Banerjee S, "Solid State Electronic Devices**"**, 6th Ed. Prentice Hall	**2005**
2.	Sze S M, "Semiconductor Devices Physics and Technology**",** John Wiley and Sons, 2nd Ed.	**2003**
3.	Tyagi M S, "Semiconductor Materials and Devices**"**, John Wiley and Sons	**2000**
4.	Chattopadhyay D and Rakshit P C, "An advanced course in Practical Physics", New Central Book Agency (P) Ltd., 7th Ed.	**2005**
5.	Gupta S L and Kumar V, "Practical Physics" 25th Ed. Pragati Prakashan	**2002**
6.	Paul P, Malvino A and Miller M, " Basic Electronics: A Text-Lab Manual", Tata McGraw Hill	**1999**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-321** Course Title: **Fabrication and Measurement Techniques**

2. Contact Hours: **L: 2** **T: 0** **P: 4**

3. Examination Duration (Hrs.): **Theory: 2** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: To impart knowledge of various fabrication and measurement techniques.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Role of Thin films in Technology and Devices, Introduction to Vacuum, Vacuum Pumps: Rotary pump, Diffusion Pump, Turbomolecular and Cryopumps, Vacuum systems, Vacuum gauges: Pirani gauge, Penning gauge	04
2.	Thin Film Synthesis using PVD & CVD techniques, Thermal evaporation, Sputtering, Molecular Beam Epitaxy (MBE), Pulsed Laser Deposition (PLD), Chemical Vapor deposition (CVD), Spin and dip coating	06
3.	Introduction and limitation of photolithography, X-ray lithography, Electron beam lithography, Nanoimprinting and soft nanolithography, Dip pen nanolithography	08
4.	Measurement of Electrical, Dielectric and Optical Properties, Four probe method, UV-visible Spectroscopy, Ellipsometry, Measurement of magnetic properties using Vibration sample magnetometer (VSM) and Superconducting Quantum Interference Devices (SQUID), Structural Characterization of Materials, X-ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM)	10
	Total	**28**

List of Experiments:

1) Deposition of Aluminum (Al) thin film using thermal evaporation
2) Measurement of thin film thickness and optical constants using ellipsometry
3) Deposition of Copper (Cu) thin films using DC-sputtering
4) Resistivity measurement of Al and Cu thin film using four probe method
5) Structural characterization of Cu and Al thin films to determine grain size, surface morphology, thickness and crystal structure
6) Preparation of 3-D bulk materials (superconductor, ferromagnetic, ferroelectric) using solid state reaction method
7) Resistivity and AC susceptibility measurements of bulk materials using physical quantities measurement systems
8) Fabrication of printed circuit board from Cu thin films
9) Dielectric constant measurements of $BaTiO_3$ material as a function of temperature
10) I-V measurements of solar cells and determination of fill factor (FF), efficiency and operating point
11) Measurement of pressure in vacuum chambers using rotary and diffusion pumps
12) Measurement of transmittance of thin film by using spectrophotometer

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Madou M, “Fundamentals of Microfabrication”, CRC Press	1997
2.	Fahrner W R, “Nanotechnology and Nanoelectronics”, Springer	2005
3.	Waits R K, “Thin film deposition and patterning”, American Vacuum Society Monograph Series	1998
4.	Tu K N, Mayer J W and Feldman L C, “Electronic Thin Film Science for Electrical Engineers and Materials Scientists”, Macmillan USA	1992
5.	Poole C P, “Introduction to Nanotechnology”, John Wiley and Sons	2003
6.	M. Ohring, “Materials science of thin films”, Academic Press	2002
7.	Callister D. Jr., “Materials Science and Engineering: An Introduction”, William John Wiley and Sons, 6^{th} Ed.	2003
8.	Chopra K L, “Thin Film Phenomena”, McGraw Hill	1979
9.	Agranovich V, “Thin Films and Nanostructures”, Elsevier	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-323** Course Title: **Radiation Detection and Measurements**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 03** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 04** 6. Semester**: Autumn** 7. Subject Area: **DEC**

8. Pre-requisite**:** **None**

9. Objective of Course: To impart the knowledge on methods of radiation detection, various types of radiation detectors and applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Radioactive decay, Source of charged and uncharged radiation, Interaction of radiation with matter: heavy charged particle, electron, gamma-rays and neutrons, stopping power, Bragg curve, Radiation exposure, absorbed dose, equivalent dose, Counting statistics, Error analysis	**10**
2.	Properties of radiation detectors: operation mode, pulse height spectra, energy resolution, detection efficiency and dead time. Ionization chambers, Proportional counters, Geiger Mueller counters. Scintillation detectors: Inorganic and Organic scintillators, photomultiplier tube, Response of scintillation detectors to gamma-rays, charged particles and neutrons. Application of scintillation detectors	**12**
3.	Semiconductor diode detectors and its use in alpha spectrometry, fission fragment spectroscopy, particle identification, X-ray spectroscopy. Gamma spectroscopy with Silicon (Si(Li)) and Germanium (Ge(Li), HPGe) detectors, Fast and slow neutron detection, Pulse processing electronics: NIM: Amplifier, SCA, CFD, CAMAC: ADC, TDC, Timing and coincidence measurements	**12**
4.	Nuclear reactor: neutron source and power generator, Applications in tracing, material modification, sterilization, material modification; neutron activation analysis, medicine: CT, PET, SPECT, MRI, therapy	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Knoll Glenn F, “Radiation Detection and Measurement”, Wiley India Pvt Ltd, 4th Ed.	2010
2.	Leo W R, “Techniques for Nuclear and Particle Physics experiments”, Springer-Verlag	1994
3.	Ahmed S, “Physics and Engineering of Radiation Detection”, Academic Press	2007
4.	Kapoor S S and Ramamurthy V, “Nuclear Radiation Detectors”, New Age International (P) Ltd.	2005
5.	Lamarsh John R and Baratta Anthony J., “Introduction To Nuclear Engineering”, Prentice Hall.	2001
6.	Gilmore Gordon R, “Practical Gamma-ray Spectrometry”, John Wiley and Sons, 2nd Ed.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-325** Course Title: **Atmospheric Physics and Climate Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: To introduce the basics of Atmospheric Physics and familiarize students with dynamics of lower atmosphere and climate.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Evolution:** Solar radiation, early atmosphere and evolution to present day atmosphere, carbon budget, ozone chemistry, variation of temperature, density, ionization and pressure with altitude, hydrostatic equation, hypsometric equation	**6**
2.	**Thermodynamics of Atmosphere:** Humidity variables, moist air, adiabatic expansion of unsaturated air, various lapse rates, vertical mixing, vertical stability of atmosphere, use of thermodynamic diagrams, role of convective potential energy	**6**
3.	**Lower Atmosphere:** Atmospheric absorption and greenhouse effect, atmospheric aerosols, origin and classification of aerosols, cloud formation, precipitation, cloud morphology, stability and clouds, growth of cloud droplets, physics of lightning, global radiation budget	**6**
4.	**Upper Atmosphere:** Introduction to ionosphere, role and features of ionosphere, Chapman theory of layer production, photochemistry of thermosphere, electron, ion and neutral temperatures, negative ions, the composite F layer, airglow and auroral emissions, measurement of ion and electron densities using ground based and space borne techniques	**6**

5.	**Atmospheric Circulation:** Equations of motion, Reynold stresses, Ekman's solution, ITCZ, vorticity, inertial instability, barotropic and baroclinic instability, energy and angular momentum transport, circulation theorems and their applications, Helmholtz theorem for split of horizontal wind vector. Vorticity, cyclones and divergence equations, scale analysis, split of vorticity and divergence equations into rotational and irrotational terms	**10**
6.	**Climatology:** Definition of climate, physical factors of climate, El Niño, Earth-Sun relationship, Koppen and Thornthwaite classification of climate, climate zones of India, pressure, wind, temperature and rainfall distribution during the four seasons. Western disturbances, fog, thunderstorm, hail, cold waves, subtropical jet stream, monsoons	**8**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Salby M L, "Fundamentals of Atmospheric Physics", Academic Press	1996
2.	Wallace J M and Hobbs Peter V, "Atmospheric Science, An Introductory Survey", Academic Press	2006
3.	Ratcliffe J A, "An Introduction to the Ionosphere and Magnetosphere", Cambridge University Press	1972
4.	Holton J R, "An Introduction to Dynamic Meteorology", Elsevier Academic Press	2004
5.	Houghton J, "The Physics of Atmospheres", Cambridge University Press	2002
6.	Tsonis A A, "An Introduction to Atmospheric Thermodynamics", Cambridge University Press	2007
7.	Citchfield H J, "General Climatology", Prentice-Hall of India	1994
8.	Rogers R R, "A Short Course in Cloud Physics", Pergamon Press	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-327** Course Title: **Physics of Nanosystems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: PHN-211**

9. Objective: This course on physics of nanosystems is designed to introduce the emerging area of nanotechnology.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction -** An overview of quantum mechanical concepts related to low-dimensional systems	2
2.	**Hetrostructures –** Heterojunctions, Type I and Type II heterostructures, Classification of Quantum confined systems, Electrons and holes in Quantum wells, Electronic wavefunctions, energy subbands and density of electronic states in Quantum wells, Quantum wires, and Quantum dots, Effective mass mismatch in heterostructures, Coupling between Quantum wells, Superlattices	5
3.	**Electron states** - Wavefunctions and Density of States for superlattices, Excitons in bulk, in Quantum structures and in heterostructures, The unit cell for quantum well, for quantum wire and for quantum dot	6
4.	**Nanoclusters and Nanoparticles –** introduction, Metal nanoclusters-Magic numbers, Geometric structures, Electronic structure, Bulk to nanotransition, Magnetic clusters; Semiconducting nanoparticles; Rare-gas and Molecular clusters	4
5.	**Carbon Nanostructures –** Introduction, Carbon molecules, Carbon clusters, Structure of C60 and its crystal, Small and Large Fullerenes and Other Buckyballs, Carbon nanotubes and their Electronic structure	3
6.	**Properties of Nano Materials:** Size dependence of properties, Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties	4

7.	**Nanomaterial Characterization:** Electron Microscopy, Scanning Probe Microscopies, near field microscopy, Micro- and near field Raman spectroscopy, Surface-enhanced Raman, Spectroscopy, X-ray photoelectron spectroscopy	7
8.	**Synthesis of nanomaterials:** Fabrication techniques: Self-Assembly, Self-Replication, Sol-Gels. Langmuir-Blodgett thin films, Nanolithograph, Bio-inspired syntheses, Microfluidic processes, Chemical Vapor Deposition, Pulse laser deposition	8
9.	**Applications of Nanomaterials:** Nanoelectronics, Nanosensors, Environmental, Biological, Energy Storage and fuel cells	3
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication / Reprint**
1.	Edelstein A A and Cammarata R C, “Nanomaterials- Synthesis, Properties and Applications”, Institute of Physics Publishing, London	1998
2.	Shik A, “Quantum Wells: Physics and Electronics of two-dimensional systems”, World Scientific	1999
3.	Benedek et al G, “Nanostructured Carbon for advanced Applications”, Kluwer Academic Publishers	2001
4.	Harrison P, “Quantum Wells, Wires, and Dots: Theoretical and Computational Physics”, John Wiley	2000
5.	Mitin V V, Kochelap V A and Stroscio M A “Quantum Heterostructures: Microelectronics and Optoelectronics”, Cambridge University Press	1999
6.	Poole Jr CP and Owens F J, “Introduction to Nanotechnology”, Wiley India.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-329** Course Title: **Superfluidity and Superconductivity**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: PHN-206**

9. Objective: It introduces advanced concepts of superfluidity and superconductivity and their interrelationship.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Superfluidity:** Basic properties of superfluid ^{4}He and ^{3}He; Bose- Einstein condensation in an Ideal Bose Gas; Bose-Einstein Condensation in Interacting Gases, Condensate Wave Function	8
2.	**Theory of Bose Fluids:** Landau Criterion for Superfluidity. Excitations in a uniform Gas – Bogoliubov Transformation; Excitations in a Trapped Gas – Weak Coupling, Excitations in Non-uniform Gases	9
3.	**Vortex States:** Quantization of Circulation, Quantized Vortices in He-II; Quantized Vortices in Superconductors; Comparison of He-II and Superconducting Vortices; Dynamics of Vortex States	9
4.	**Ginzburg-Landau Theory:** Ginzburg Landau equations, second order critical fields; Abrikosov vortex lattice; Relation of GL theory with BCS theory; Ginzburg-Pitaevskii equations for He-II; Broken symmetry	8
5.	**High-Tc Superconductivity:** Nature and various mechanisms of High Tc superconductivity; Equation for the critical temperature and strong electron-phonon coupling; SDW and CDW	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Chaikin P M and Lubensky T C, “Principles of Condensed Matter Physics”, Cambridge University Press	**1995**
2.	Tilley D R and Tilley J, “Superfluidity and Superconductivity” (3rd Ed.), Overseas Press	**2005**
3.	Suneto T and Nakahara M,“Superconductivity and Superfluidity”, Cambridge University Press	**2005**
4.	Pethick C J and Smith H, “Bose-Einstein Condensation in Dilute Gases”, Cambridge University Press	**2002**
5.	Pitaevskii L and Stringari S, “Bose-Einstein Condensation”, Clarendon Press	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-331** Course Title: **Nuclear Astrophysics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: PHN-211**

9. Objective: To introduce the emerging field of nuclear astrophysics which attempts to understand how nuclear processes generate the energy of stars over their lifetimes and synthesize heavier elements.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction :** Astronomy-Observing the universe**,** Astrophysics- 'Explaining' the universe; General characteristics of Thermonuclear reactions; Sources of nuclear energy; Cross sections, stellar reaction rates, mean lifetime; Maxwell-Boltzmann velocity distribution, Astrophysical *S* – factor	10
2.	**Determination of reaction rates :** Neutron and charged particle induced non-resonant reactions**;** Reactions through narrow and broad resonances	8
3.	**Hydrogen and Helium burning :** p-p chain, CNO cycles, other cycles like NeNa, MgAl; Creation and survival of ^{12}C	9
4.	**Explosive Burning and Nucleosynthesis beyond Iron :** Silicon burning**;** Nucleosynthesis in massive stars**,** *s* – process, *r* - process	9
5.	**Indirect methods in Nuclear Astrophysics :** Coulomb dissociation, Trojan Horse and ANC methods; Neutron stars; Radioactive Ion Beams	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Rolfs C E and Rodney W S, “Cauldrons in the Cosmos : Nuclear Astrophysics”, The University of Chicago Press	**2005**
2.	Clayton D D, “Principles of Stellar Evolution and Nucleosynthesis”, The University of Chicago Press	**1984**
3.	Glendenning N K, “Compact Stars”, Springer	**2000**
4.	Boyd R, “An Introduction to Nuclear Astrophysics”, The University of Chicago Press	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-314** Course Title: **Nanotechnology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**: PHN-211**

9. Objective: The course is designed to introduce the emerging area of nanotechnology that has potential to revolutionize techniques by which materials and products will be created in the future with new and superior properties and functionalities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Historical development, Scientific Revolutions, Opportunity at the nano scale, Classification of functional nanomaterials	02
2.	**Fundamental Principles:** Size & Scale, units, Scaling Laws, Atoms, Molecules & Clusters, Quantum wells, wires and Dots – Size and dimensionality effects	04
3.	**Properties of Nano Materials:** Size dependence of properties, Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties	05
4.	**Nanomaterial Characterization:** X-Ray Diffraction, Scanning electron microscopy, Transmission electron microscopy, Atomic force microscopy, Scanning tunneling microscopy, Thermogravimetric Analysis – Differential Scanning Calorimetry – Thermomechanical Analysis-.X-ray photoelectron spectroscopy	10
5.	**Fabrication techniques**: Mechanical alloying and mechanical milling, Self-Assembly, Sol-Gels. Langmuir-Blodgett thin films, Nanolithography, Chemical Vapor Deposition, Physical Vapor deposition and different types of epitaxial growth techniques-pulsed laser deposition - Magnetron sputtering - Micro lithography (photolithography, soft lithography, e-beam writing, and scanning probe patterning)	10

6.	**Nanomaterials:** Single walled carbon nanotubes (SWNTs), Multiwall carbon nanotubes (MWNTs), graphenes, fullerenes: structure and properties, Metal/oxide nanoparticles, nanorods, nanowires, nanotubes, and nanofibers, Semiconductor Quantum Dots: Excitons, Magnetic Nanoparticles: Nanostructured Ferromagnetism	08
7.	**Applications of Nanomaterials:** Nanoelectronics, Nanosensors, Environmental and Biological applications, Energy Storage and fuel cells	03
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Edelstein A A and Cammarata R C, "Nanomaterials- Synthesis, Properties and Applications", Institute of Physics Publishing, London	1998
2.	Nalwa H S, "Handbook of Nanostructured Materials and Nanotechnology", Vols. 1-5, Academic Press	2000
3.	Benedek et al G, "Nanostructured Carbon for advanced Applications", Kluwer Academic Publishers	2001
4.	Dresselhaus M S, Dresselhaus G and Eklund P, "Science of Fullerenes and nanotubes", Academic Press	1996
5.	Wolf Edward L, "Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience", Wiley-VCH, 2nd Ed.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-316** Course Title: **Properties of Matter and Acoustics**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: To familiarize students with fundamentals of properties of matter, waves and acoustics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Elasticity:** Hooke's Law Stress, Strain Diagram, Elastic moduli, Relation between elastic constants, Poisson's Ratio, Expressions for Poisson's ratio in terms of elastic constants, Work done in stretching and twisting a wire, Twisting couple on a cylinder, Rigidity modulus by static torsion, Torsional pendulum, Rigidity modulus and moment of inertia, Elastic materials, Tensor of strain, Tensor of elasticity	**8**
2.	**Bending of beams:** Cantilever, Expression for bending moment, Expression for depression, Cantilever oscillations, Expression for time period, Experiment to find Young's modulus, Non uniform bending, Determine Young's modulus by Koenig's method, Uniform bending, Expression for elevation, Determine Young's modulus using microscope	**8**
3.	**Fluids:** Definition and dimensions of surface tension, Excess of pressure over curved surfaces, Application to spherical and cylindrical drops and bubbles, Variation of surface tension with temperature, Jaegar's method, Steady flow of Newtonian fluids, Poiseuille's equation for incompressible fluids: Statement of Stokes law, Terminal velocity, Effect of temperature on viscosity, Reynold's number, Turbulent flow and critical velocity, Experiment to determine co-efficient of viscosity of a liquid, Applications of viscosity. Equation of continuity-Bernoulli's theorem and conservation of energy	**10**

5.	**Waves and Oscillations:** Simple harmonic motion: Free, Damped, Forced vibrations and Resonance, Coupled harmonic oscillator, Eigen frequencies and normal modes, Transverse vibrations in stretched strings, Wave equation for a string, Velocity of transverse wave along a string, Energy of a vibrating string, Fourier's analysis for plucked and bowed string	**10**
6.	**Applications:** Spherical waves, Shock waves, Ultrasonics: Production of ultrasonic waves (Piezo electric crystal method and Magnetostriction method), Applications to industry and medical science	**6**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Feynman R P, Leighton R B and Sands M, "The Feynman Lectures on Physics", Narosa	2005
2.	Mathur D S, "Elements of Properties of Matter", S. Chand and Company, 11th Ed.	1949
3.	Flowers B H and Mendoza E, "Properties of Matter", Wiley	1991
4.	Maiti S N and Raychaudhury D P, "Classical Mechanics and General Properties of Matter", New Age International Publisher	2013
5.	Bajaj N K, "The Physics of Waves and Oscillations", Tata McGraw Hill	1988
6.	Ingard K U, "Fundamentals of Waves and Oscillations", Cambridge Univ. Press	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-318** Course Title: **Atomic and Molecular Collision Physics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **PH-204**

9. Objective: The course aims at introducing the formal scattering theory, and its applications to scattering of projectiles from atoms and molecules**.**

10. Details of Course:

Sl. No	Contents	Contact Hours
1.	**Potential scattering-I:** General features, partial wave analysis, Optical theorem and unitarity relation, the phase shifts, Absorption processes, Scattering by a complex potential, Coulomb potential in parabolic coordinates, partial wave decomposition, Scattering by a modified Coulomb field	12
2.	**Potential scattering-II:** Schrödinger equation as an integral equation, Green's function, Lippmann-Schwinger equation, Compact solutions of Lippmann-Schwinger equation, Integral representations of scattering amplitude, Partial wave analysis of Lippmann-Schwinger equation, Born expansion as a perturbation series, the first born approximation, Born Series	10
3.	**Electron – atom collisions:** Electron scattering: general principles, elastic scattering, excitation of atoms to discrete levels, ionization, resonance phenomena	6
4.	**Atom-atom collisions:** Long range interactions between atoms, the classical approximation, the elastic scattering of atoms at low velocities, electronic excitation and charge exchange	8
5.	**Electron - molecule collisions:** Theory of electron-molecule collisions, calculation of differential and integrated cross sections and illustrative results	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Joachain C J, "Quantum Collision Theroy", North Holland, 3rd Ed.	1983
2.	Bransden B H and Joachain C J, "Physics of Atoms and Molecules", Prentice Hall, 2nd Ed.	2003
3.	Gianturco F A, "Atomic and Molecular Collision Theory", Plenum Press	1982
4.	Burke P G and Joachain C J, "Theory of Electron- Atom Collisions: Potential Scattering", Springer	1995
5.	Bransden B H, "Atomic Collision Theory", Benjamin, 2nd Ed.	1983
6.	Zettili N, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd Ed.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-320** Course Title: **Fiber and Nonlinear Optics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **PHN-214**

9. Objective: To introduce applications of lasers in nonlinear optics, optical fiber communication and sensors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fiber optics:** Rectangular waveguides: optical waveguides, planar mirror waveguides, electromagnetic analysis of planar optical waveguides, TE and TM modes of a symmetric and asymmetric planar waveguide, power associated with a mode	12
2.	**Optical fiber**: optical fiber waveguide, the numerical aperture, pulse dispersion in a step-index fiber, scalar wave equation and modes of a fiber, LP modes, single-mode fibers, material and waveguide dispersion for a communication link, attenuation, splice loss, methods of fabrication of optical fibers, optical fiber components, directional coupler, multiplexer, demultiplexer, fiber Bragg gratings, long-period fiber gratings, optical fibers in sensors, photonic crystal fibers	12
3.	**Nonlinear optics:** Nonlinear optical media, nonlinear polarization and susceptibility 2^{nd} order nonlinear optics: optical second harmonic generation, sum frequency generation, difference frequency generation, optical parametric amplification and oscillation, three wave mixing	10
4.	**3^{rd} order nonlinear optics**: third harmonic generation, optical Kerr effect, self phase modulation, self focusing, spatial solitons, Raman gain, four wave mixing, optical phase conjugation, Raman and Brillouin scattering	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication / Reprint
1.	Ghatak A K and Thyagarajan K, “Optical Electronics”, Cambridge University Press	**2003**
2.	Ghatak A K and Thyagarajan K, “Introduction to Fiber Optics”, Cambridge University Press	**1998**
3.	Laud B B, “Lasers and Nonlinear Optics”, Wiley Eastern	**1992**
4.	Saleh B E A and Teich M C, “Fundamantals of Photonics”, Wiley Interscience	**2007**
5.	Snyder A and Love J, “Optical Waveguide Theory”, Chapman and Hall	**1983**
6.	Keiser G, “Optical Fiber Communications”, McGraw Hill	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-322** Course Title: **Modern Particle Physics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: DEC**

8. Pre-requisite**: PH-209, 211**

9. Objective: To introduce the basics of modern elementary particle physics**.**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Group Theory and Algebra:** Representation theory of SU(2) and SU(3) groups and Lie algebras, SU(3) flavor symmetry and construction of meson octet, baryon octet & decuplet	6
2.	**Field Theories:** Klein-Gordon equation, Dirac equation, Concept of anti-particles; Canonical Quantization	6
3.	**Elementary Particles:** Concept of elementary particles and their classification, Conservation of the different quantum numbers viz. baryon number strangeness etc in particle physics, Concept of color and quark model, Deep inelastic scattering of lepton-hadron scattering: discovery of quarks and gluons	8
4.	**Symmetries**: Noether's Theorem: Symmetry and conservation laws, Spin and Orbital Angular Momentum, Flavor symmetry, Parity, Charge Conjugation, Time reversal symmetry, CPT Theorem	6
5.	**Weak Interaction**: (i) Phenomenology: Parity violation and the V-A form of the weak current, Muon decay, Pion decay, charged current, neutral currents, Cabibbo angle, weak mixing angle, CP Invariance, CP violation; (ii) Electroweak Unification (Glashow-Salam-Weinberg model): The basic electroweak interaction, effective current-current Interaction, Spontaneous symmetry breaking, Higgs mechanism, masses of gauge bosons and fermions	10
6.	**Strong Interaction:** Yang-Mills theory, Quantum Chromodynamics, Feynman Rules, Asymptotic Freedom	4

7.	**Physics of particle production**: Colliders: past, present and future; Fragmentation functions, Jets, Production of vector bosons and heavy quarks	2
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Griffith D, “Introduction of Elementary Particles”, John Wiley	2000
2.	Sarkar U, “Particle and Astro-Particle Physics”, Francis and Taylor	2007
3.	Kane G, “Modern Elementary Particle Physics”, Addison Wesley	1993
4.	Halzen F and Martin A D, “Quarks and Leptons” John Wiley	2011
5.	Cheng T P and Li L F, “Gauge theory of Elementary Particle Physics’’, Oxford University Press	1988
6.	Barger and Phillips, Collider Physics, Addison-Wesley Publishing Company	1996
7.	Perkins D H, “Introduction to High Energy Physics”, Cambridge University Press	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN- 425** Course Title: **Superconducting Materials**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: To familiarize the students with various properties of superconductors, important superconducting materials and applications of superconductors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characteristic properties of superconducting materials:** Zero resistance, Meissner effect, critical magnetic field, critical current density, Type-I and Type-II superconductors, isotope effect, flux quantization, thermal properties of superconductors, Heat capacity, Thermal conductivity, Energy Gap, microwave properties	8
2.	**Theories of superconductors:** London's equations, Pippard theory, outline of Ginzburg Landau theory, Cooper problem, outline of BCS theory	6
3.	**Superconducting Materials:** Superconducting elements, Binary alloys and compounds, Organic superconductors, High-T_c cuprate superconductors, C- based superconductors, MgB_2 superconductor, Fe-based superconductors	6
4.	**Critical current of Type-II superconductors:** Flux quantization and vortices**,** the Abriksov lattice, flux flow, flux pinning, flux creep, irreversible properties, depairing critical current, hysteresis cycle: the Bean model, Effects of grain boundaries on J_c in high-T_c superconductors	6
5.	**Measurements of superconducting properties:** Electrical and magnetic measurement to superconductors to determine Tc, Jc, upper critical field (H_{C2}), irreversibility field (H_{irr})	6
6.	**Josephson effects:** The tunnel effect: NIN, NIS and SIS junctions, dc Josephson effect, ac Josephson effect, dc and rf SQUID	6

7.	**Technology and Applications:** Large scale and high current applications of superconductors: Superconducting magnets, magnetic levitation, NMR, MRI, Superconducting Electronics and film applications: Digital electronics, microwave applications	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Michel C and Davor P, “Introduction to superconductivity and high Tc materials”, World Scientific.	1992
2.	Kittel C, “Introduction to Solid State Physics” John Willey	1996
3.	Ramakrishnan T V and Rao C N R, “Superconductivity Today”, Pergamon Press.	1992
4.	Poole C P, Farach H A, Creswich R J and Prozorov R, “Superconductivity”, Academic Press	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-427** Course Title: **Quantum Information and Computing**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 03** **Practical: 0**

4. Relative Weight: **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits: **04** 6. Semester: **Autumn** 7. Subject Area: **DEC**

8. Pre-requisite: **None**

9. Objective of Course**:** To introduce the basic and advance principles of Quantum Information and Computing to the students.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, postulates of quantum theory, Dirac notation, quantum circuit model, Super-dense coding, quantum teleportation and no-cloning theorem	8
2.	Quantum computing: Quantum qubits, quantum logic gates, Quantum Circuits, Universal quantum gates, application of quantum computer; Deutsche's algorithm, Deutsch-Jozsa algorithm, Simon's Algorithm, Simulation of quantum system	12
3.	Quantum Fourier Transform, Grover's algorithm, Phase estimation, Quantum Factorization, Quantum searching, Shor's algorithm, Quantum search algorithms	12
4.	Quantum error-correction, Quantum error-correcting codes, Stabilizer codes, Fault-tolerant quantum computation, Physical realizations of quantum computation	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Nielsen Michael A and Chuang Isaac, “Quantum Computation and Quantum Information”, Cambridge University Press.	2012
2.	Kaye Phillip, Laflamme Raymond and Mosca Michele, “An Introduction to Quantum Computing”, Oxford University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-429** Course Title: **Nuclear Science and Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: PHN-208**

9. Objective: To introduce developments in the fields of nuclear science and technology, and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Nuclear Physics Fundamentals :** Properties of nuclei, Nuclear structure and stability, Radioactivity, Interaction of charged particles, neutrons and gammas with matter, Fission and Fusion	6
2.	**Reactor Fuels and Fission Based Reactors:** Reactor fuels, conversion and breeding, components of nuclear power plants, light water reactor, pressurized water reactor, boiling water reactor, breeder reactors, Nuclear fuel cycles, Uranium enrichment, radioactive waste disposal	9
3.	**Reactor Physics:** Neutron Flux, diffusion equation and its solution, thermal neutron diffusion, two-group calculation of neutron moderation, fusion based reactors, ITER, Confinement of Plasma	6
4.	**Accelerators:** Review of relativistic particle motion, Types of particle accelerators – Direct-voltage accelerators (Cockcroft Walton, Van de Graff, Pelletron), radio-frequency [RF] accelerators viz., betatron, synchrotron, cyclotron, linear accelerator [LINAC]	5
5.	**Beam Optics:** Equations of motion for weak and strong focusing, Matrix elements for beam optics – dipole, quadrupole and solenoid magnet, focusing-defocussing (FODO) lattice and stability diagrams, RF acceleration dynamics, Phase Space representation - Ensemble of Particles, Emittance, Synchrotron Radiation	7

6.	**Modern Accelerators:** Superconducting RF LINACS, Novel acceleration schemes – Fixed Field Accelerating Gradient (FFAG) accelerator, Dielectric Wall Accelerator, Laser accelerators	**3**
7.	**Applications :** Medical imaging, Nuclear physics applications in clinic and medical research, Radiation and hadron therapy, Radioisotopes in food and health, Dosimetry and radiation protection	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Knoll Glenn F, "Radiation Detection and Measurement", John Wiley and Sons, 4th Ed.	2010
2.	Lamarsh John R and Baratta Anthony J, "Introduction To Nuclear Engineering", Prentice Hall, 3rd Ed.	2001
3.	Shultis J K and Faw R E, "Fundamentals of Nuclear Science and Engineering", Marcel Dekker	2002
4.	Stacey W M, "Nuclear Reactor Physics", Wiley-VCH, 2nd Ed.	2007
5.	Almenas K and Lee R, "Nuclear Engineering: An Introduction", Springer-Verlag, 2nd Ed.	1992
6.	Conte Mario and Mackay William W "An Introduction to the Physics of Particle Accelerators", World Scientific, 2nd Ed.	2008
7.	Wille K, "The Physics of Particle Accelerators: An Introduction", Oxford Univ. Press	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-431** Course Title: **Weather Forecasting**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **None**

9. Objective: To familiarize with the dynamic meteorology of earth's atmosphere.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atmospheric Dynamics:** Equation of motion, the geostrophic approximation, cyclostrophic motion; The thermal wind equation; The equation of continuity	8
2.	**The General Circulation:** A symmetric circulation, Inertial instability, Barotropic instability; Baroclinic instability; Sloping convection; The general circulation of the middle atmosphere	8
3.	**Numerical Modelling of Weather:** A barotropic model; Baroclinic models; Primitive equation models; Moist processes; Radiation transfer; Forecasting models	10
4.	**Global Observations:** Conventional observations; Remote sounding from satellites; Remote sounding of atmospheric temperature; Remote measurements of composition	8
5.	**Atmospheric Predictability and Climate change:** Short term predictability; Variations of climate; Atmospheric feedback processes; Different kind of predictability	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Houghton J T, “The physics of atmospheres”, Cambridge University Press	1997
2.	Holton J R, “Introduction to dynamic meteorology”, Academic Press	1992
3.	Zdunkowski W and Boot A, “Dynamics of the Atmosphere”, Cambridge University Press	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-433** Course Title: **Introduction to Superstring Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite: PHN-209

9. Objective: The main objective of this course is to prepare the student with the basics of superstring theory.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Bosonic String Theory: Perturbative: free bosonic string in Minkowski space, commutation relation and mode expansion, Virasoro algebra, Light-cone gauge Quantization and no-ghost theorem, analysis of spectrum	8
2.	Superstring Theory:World-sheet supersymmetry, boundary conditions and mode expansions, light-cone gauge quantization, [no-ghost theorem, GSO condition], extended world-sheet supersymmetry [N=2, 4], super Yang-Mills theory	14
	Space-time supersymmetry, superparticle and superstring, type I and II superstrings, Light-cone quantization and analysis of open and closed-string spectra	
	SO(32) and E_8 x E_8 heterotic string theories	
3.	Basic Mathematics of String Theory: Topological Spaces, Continuous Functions, real (differentiable) manifolds, vector fields, differential forms, Riemannian Geometry, integrals of forms and Stokes theorem, Laplacian on forms, Simplicial Homology, de Rham Cohomology, Fiber Bundles, Homotopy theory, Complex Manifolds, Kählerian geometry, Dolbeault Cohomology, Calabi-Yau manifolds and their Moduli Spaces	8
4.	Nonperturbative: dualities, basic ideas of M- and F -theories, compactifications, dualities, examples and their tests and interrelation between different duality conjectures, M-theory in 11 dimensions and its compactification, F-theory in 12 dimensions and its compactifications, nonperturbative D-branes and open strings in closed string theories	12
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Green Michael B, Schwarz John H and Witten Edward, “Superstring Theory: Volume 1, Introduction”, Cambridge University Press	1988
2.	Polchinksi J, “String Theory”, Cambridge Monographs on Mathematical Physics, Volumes 1and 2	1998
3.	Sen Ashoke, “An Introduction to Nonperturbative String Theory: Duality and supersymmetric theories”, Cambridge	1997
4.	Greene Brian R, “String theory on Calabi-Yau Manifolds”, (Columbia U.) : Lectures given at Theoretical Advanced Study Institute in Elementary Particle Physics (TASI 96): Fields, Strings, and Duality, Boulder, CO, 2-28 Jun 1996, Published in Boulder 1996, Fields, *Strings and* Duality, World Scientific Singapore	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-435** Course Title: **Advanced Characterization Techniques**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **None**

9. Objective: To introduce the various methods of characterization of materials for their structural, electrical, magnetic and optical properties.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Crystal Structure Determination:** Brief description of Crystal Lattices; X-ray diffractometer; Determination of Crystal Structure using X-ray diffraction	12
2	**Electron Microscopes:** Brief description of different microscopes like TEM, SEM, AFM; Different modes of operation of microscopes, sample preparation, Interpretation of electron diffraction and determination of Crystal Structure; Morphology of the Crystals	11
3	**Thermal Analysis:** Thermogravimetric analysis, Differential thermal analysis and Differential scanning calorimetry and methodology; Determination of phase transitions using these methods	05
4	**Electrical and Magnetic Property:** Measurement of Electrical conductivity in different materials, e.g. insulators, metals and semiconductors. Using Four Probe and Hall Effect method. Vibrating Sample Magnetometer (VSM), Superconducting Quantum interference Devices (SQUID), Magnetodielectric effect	8
5	**Optical Characterization:** Optical characterization of materials using Photoluminescence and UV-visible spectroscopy	03
6	**Chemical Analysis:** Brief description to X-ray fluorescence, Atomic absorption and electronic spin resonance spectroscopy	03
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication / Reprint
1.	Culity B D, “Elements of X-ray Diffraction”, Addison-Wesley	**2001**
2.	Grundy P J and Jones G A, “Electron Microscopy in the Study of Materials”, Edward Arnold	**1976**
3.	Egerton R F, “Physical Principles of Electron Microscopy”, Springer	**2008**
4.	Willard, Merritt, Dean and Settle, “Instrumental Methods of Analysis”, CBS publications	**1991**
5.	Fultz B and Howe J M, “Transmission Electron Microscopy and Diffractometry of Materials”, Springer	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-437** Course Title: **A Primer in Quantum Field Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **PHN-209**

9. Objective: To familiarize students with applications of relativistic quantum mechanics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basics:** Action principle; Euler-Lagrange equations of motion, second quantization; Symmetry (space-time and internal) Conserved Nöther charges	4
2.	**Tensors:** Definitions of contravariant, covariant and mixed tensors, need to use tensors in relativistic quantum mechanics.	2
3.	**Spin-0 (Klein Gordon Field Theory):** Real scalar field theory and its canonical quantization; Normal Ordering; Charged scalar field theory and its canonical quantization, conserved Nöther current and charge, Propagator (also as vacuum expectation value of a time-ordered product), interpretation of negative-energy solutions as anti-matter; Recasting Klein-Gordon equation as a Schrödinger equation, Zitterbewegung	7
4.	**Spin-1/2 (Dirac Field Theory):** Dirac Lagrangian for spinor fields, Feynman Gamma matrices and related identities; Covariance of the Dirac equation; Canonical quantization of the spinor fields, positive- and negative-energy spinors, positive- and negative-energy projectors, Lorentz transformations to boost from rest frame to lab frame; Propagator (also as vacuum expectation value of a time-ordered product), Discrete symmetries: Charge conjugation, Parity and Time reversal symmetries	9
5.	**Spin-1 (Gauge Field Theory):** Covariant formulation of Maxwell's equations, (transverse) canonical quantization of the gauge field (in the Coulomb gauge),	5
6.	**Scattering**: LSZ reduction (for bosons and fermions), Wick's theorem, S-matrix, cross sections	6
7.	**Quantum Electrodynamics**: Quantization of abelian gauge theories with fermions; Feynman Rules; Compton effect; Møller Scattering, radiative corrections; Anomalous Magnetic Moment; Infrared Divergence; Lamb shift	9
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Michio K, Quantum Field Theory: A Modern Introduction, Oxford University Press	1993
2.	Claude I and Jean B Z, "Quantum Field Theory, McGraw Hill	2006
3.	Lewis H R, "Quantum Field Theory", Cambridge University Press	2001
4.	Michael E P, "An Introduction to Quantum Field Theory, Perseus Books Publishing	2002
5.	Lahiri A and Pal P B**,** A First Book of Quantum Field Theory**,** Narosa Publishing House	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-422** Course Title: **Emerging Phenomena in Materials**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **PHN-206**

9. Objective: To introduce students to the research and application potential of the new emerging phenomena in materials

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Spintronics:** Introduction to spintronics, spin injection, spin detection, spin relaxation, spin polarization, Giant Magnetoresistance (GMR), Colossal Magnetoresistance (CMR), Tunneling Magnetoresistance (TMR), magnetic multilayers, exchange bias, spin diode, magnetic tunnel junctions, spin-field effect transistor	**10**
2.	**Oxide heterostructures:** Band insulator and Mott insulator, Properties of transition metal oxides, polar/non-polar nature of thin film interfaces, polar catastrophe, 2D metallic interface, Functional properties of oxide interfaces (superconductivity, magnetism etc.), Multiferroics	**10**
3.	**Graphene:** Band structure of graphene, Dirac spectrum and Fermi points at half filling, tunneling and Klein paradox, devices based on graphene	**6**
4.	**2D electron gas:** Experimental realization of 2D electron gas**,** Integer and fractional quantum Hall effect	**4**
5.	**Topological insulators:** Fundamentals and materials, experimental observations, idea of edge states, Rashba spin-orbit coupling and its consequences	**4**
6.	**High Tc superconductors:** Experimental observations: Temperature dependence of resistivity and specific heat, deviation from standard BCS behavior, phase diagram and electronic structure of $La_{2-x}Sr_xCuO_4$, ARPES spectra: d-wave symmetry of the order parameter	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Cahay Marc and Bandyopadhyay Supriyo, "Introduction to Spintronics", CRC press	2008
2.	Evgeny Y. Tsymbal, Elbio R A Dagotto, Chang-Beom Eom and Ramamoorthy Ramesh, “Multifunctional Oxide Heterostructures”, Oxford University Press	2012
3.	Maekawa Sadamichi, “Physics of Transition Metal Oxides”, Springer-Verlag	2004
4.	Bernevig B Andrei and Hughes Taylor L, “Topological insulators and topological superconductors”, Princeton University Press	2013
5.	Ashcroft N W and Mermin N D, “Solid State Physics”, Harcourt Asia Pvt. Ltd.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN - 424** Course Title: **Optoelectronics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **None**

9. Objective: To impart knowledge about working principles of different Optoelectronics devices for science and engineering applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Semiconductors and their Optical Properties** Semiconductors- energy bands and charge carriers, binary, ternary and quaternary semiconductors, generation, recombination and injection processes, junctions, hetrojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absorption and emission, rates of absorption and emission, refractive index	**7**
2.	**Semiconductor Light Emitting Devices** Light emitting diodes, injection electroluminescence, LED characteristics, Quantum Efficiency, Responsivity, semiconductor laser amplifier, gain, pumping, hetrostructures, semicunductor injection lasers, amplification, feedback and oscillation, power, spectral distribution, mode selection, characteristics of typical semiconductor lasers, quantum well lasers, VCSELS, LCD, Plasma Display	**12**
3.	**Photodetectors** Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, Photoconductors-photodiodes, p-n and p-i-n photodiode, avalanche photodiodes, noise in photodetectors, Phototransistors, Photoconductive Gain, CCD and CMOS sensors	**8**

4.	**Photovoltaics Devices** Solar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices, and efficiencies, Organic Solar Cells, CIGS Solar Cells, Perovskite Solar Cells	**8**
5.	**Optical Communication Systems** Characteristics of optical fiber, Single and Multi-mode fiber, step-index, graded-index, Attenuation and Dispersion, optical fiber components,	**7**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Saleh B E A and Teich M C, "Fundamentals of Photonics", John Wiley and Sons, Inc.	1991
2.	Ghatak A and Thyagarajan K, "Optical Electronics", Cambridge University Press	2003
3.	Kasap S O, Optoelectronics and Photonics: Principles and Practices, Prentice Hall	2001
4.	Streetman B G and Banerjee S, "Solid State Electronic Devices", 6 Ed. Prentice Hall	2006
5.	Chuang Shun Lien , "Physics of optoelectronic devices", Wiley	1995
6.	Wilson John and Hawkes John, "Optoelectronics, an introduction", Prentice Hall, 3rd Ed.	1998
7.	Singh J, "Optoelectronics: An introduction to materials and devices", McGraw-Hill	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-426** Course Title: **Space Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: To familiarize students with the basic principles space technology and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Earth and Orbiting Satellites:** Basic Principles, Keplerian orbits and Kepler equations, Orbital elements from velocity and position information, Perturbation theory and applications	**8**
2.	**Rocket and Rockets Propulsion:** Thrust Equation, Specific Impulse, Rocket Equation, propulsion options and advanced propulsion concepts, Electromagnetic propulsion, ion propulsion, Different types of launch vehicles of ISRO, NASA, ESA	**8**
3.	**Satellite Navigations:** Global navigation satellite systems, GPS, IRNSS, GLONASS, Galileo	**5**
4.	**Satellite Communications:** Theory of radio wave propagation through ionosphere, Earth to satellite communication, laser communication, satellite to satellite communication	**7**
5.	**Indian Scientific Space Missions:** Chandrayaan-1 &2, Mars Orbiter Mission, Astrosat, Aditya-1	**5**
6.	**Applications of Space Technology:** Physics of the Earth's atmosphere, Solar observations in infrared, visible and X-rays; Communication Satellite and applications, Earth resource monitoring, remote sensing and others, military applications, weather satellite and applications	**9**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hans M, "Space Science and Technology", John Wiley and Sons	2003
2.	Emilio C and Alfredo H, "Fundamentals of Satellite Remote Sensing, Taylor and Francis	2009
3.	Rao K N R, "Fundamentals of Satellite communications", Prentice-Hall of India Pvt. Ltd.	2006
4.	Verger E T, "The Cambridge Enclyopedia of Space, Missions, Applications and Exploration", Cambridge University Press	2003
5.	Uberoi C and Chaicravorty S C, "Space Environment and it's Interaction With Spacecraft", USc-ISRO Educational Program.	2000
6.	Garner J T and Gones M, "Satellite Operations, Systems Approach to Design and Control", Ellis Horwood.	1990
7.	Kaula W M, "Theory of Satellite Geodesy Applications of Satellite Geodesy", Mineola Dover Publications.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-428** Course Title: **Advanced Electroceramics Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**: None**

9. Objective: This course will introduce modern day electoceramic materials, their applications and the underlying physical principles.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	INTRODUCTION: Oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties	4
2.	POWDER PREPARATION: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction)	6
3.	BASIC PRINCIPLES AND TECHNIQUES OF CONSOLIDATION AND SHAPING OF CERAMICS: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering	5
4.	Sintering: different mechanisms and development of microstructure (including microwave sintering) Preparation of single crystal, thick and thin film ceramics Problems of sintering: Inhomogeneties and their effects on sintering, constrained sintering; rigid inclusion, thin film, solid solution additives and the sintering, sintering with chemical reaction, viscous sintering with crystallization	5
5.	EXOTIC CERAMICS: functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications, Ceramic Sensors, Transparent ceramics, coatings and films: preparation and applications	8

6.	Ceramic Capacitors: Historical Background, Ferro Electricity in Capacitors Technology, Dielectric Properties of Multi-Phase systems, Basic Dielectric Materials, Varieties of Ceramic capacitor, Capacitor performance Parameters, Typical Ceramic Dielectric Compositions, fuel cells and batteries	8
7.	Magnetic Ceramics: Spinal ferrites, Hexagonal ferrites, Rare earth-Garnet, Processing & application in various fields	6
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Barsoum, M W, "Fundamental of Ceramics", McGraw Hill	1997
2.	Richardson D W and Lee W E, " Modern Ceramic Engineering", Marcel Dekker, 3rd Ed.	1992
3.	Rahman M N, "Ceramic Processing and Sintering", Marcel Dekker	2003
4.	Somiya S, "Handbook of Advanced Ceramics", Academic Press	2003
5.	Somiya S, "Handbook of Advanced Ceramics, Parts 1 and 2, Academic Press	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-430** Course Title: **Solar Terrestrial Physics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **PHN-325**

9. Objective: Aspects of solar interaction with Earth's upper atmosphere

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**The sun and interplanetary space:** The sun as a star, solar atmosphere, solar electromagnetic radiations, variance in the solar spectra, solar wind, solar and interplanetary magnetic field, solar cycle variations, cosmic rays in the interplanetary space, interaction of solar wind and other planets.	**6**
2.	**The Physics of Geospace:** Properties of gases, Magnetoplasma, Gyrofrequency, plasma frequency, waves, radio wave propagation in ionized medium, waves propagation in plasma, Langmuir wave, ion-acoustic wave, electromagnetic wave in unmagnetized plasma, plasma instabilities.	10
3.	**Dynamo action:** Equations of motion of terrestrial atmosphere, the atmospheric circulation, heating of upper atmosphere, tidal oscillations of the atmosphere, the lunar tide, the solar tides, tides at the ionospheric level, motion of charged particles, conductivities, Layer conductivity	10
4.	**Ionosphere:** Physical aeronomy, chemical aeronomy, formation of D, E, F1 and F2 regions in low and mid latitudes, Ionospheric electric currents, F-region drifts, ion drag effects, storms, geomagnetic indices, irregularities in ionosphere, travelling ionospheric disturbances.	10
5.	**Whistlers:** Whistlers and VLF emissions, Emission theories, dispersion relation for whistler mode wave, growth rate calculation, nonlinear effects, quasilinear theory, diffusion into loss cone.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Seeds M A, “Solar System”, Brooks/Cole Thomson Learning	2007
2.	Das A C, “Space Plasma Physics”, Narosa Publishing House	2004
3.	Hargreaves J K, “The solar-terrestrial environment”, Cambridge Atmospheric and Space Science Series	2003
4.	Akasofu Syun-Ichi, Sydney Chapman, Solar-Terrestrial Physics, Oxford Press	1972
5.	Kelley M C, “The Earth’s Ionosphere”, Academic Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE**:** **DEPARTMENT OF PHYSICS**

1. Subject Code:**PHN-432** Course Title: **Computational Nuclear Physics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 00** **MTE: 25** **ETE: 50** **PRE: 00**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** PHN-208

9. Objective: To understand the concepts of nuclear physics through numerical solutions obtained by writing computer programs

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Harmonic oscillator, wave functions, evaluation of special functions using recurrence relations and optimization, spherical harmonics, shapes of atomic orbitals, Coupling of angular momenta.	**5**
2.	Simulation of Rutherford scattering, Semi empirical mass formula, estimation of the constants in mass formulae using atomic mass evaluations, mapping of drip lines. Quantum tunneling: application of WKB approach to alpha and proton decays.	**5**
3.	Numerical evaluation of Eigen states for different potentials by solving coupled differential equations with boundary conditions, harmonic oscillator, square-well and Woods-Saxon potentials. Complex Eigen values and resonances	**5**
4.	Independent particle models, Eigen states, Solutions for Nilsson model. Single-*j* shell approximation and Cranking model. Effective interaction: Simple estimates, Evaluation of matrix elements in sd shell. Superconductivity: Solution for BCS equations at $T = 0$. Hot nuclei: Application of Fermi-Dirac distribution. Quantum Hadrodynamics: Walecka model, Equation of State for symmetric, asymmetric and neutron star matter	**10**
5.	Setting up large codes, parallel and distributed computing, open access codes, libraries	**3**
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Greiner W and Maruhn J A, “Nuclear models”, Springer-Verlag	1997
2.	Arfken G B, Weber H J and Harris F E, “Mathematical Methods for Physicists”, Academic Press, 7th Ed.	2013
3.	Abramowitz M and Stegun I A, “Handbook of mathematical functions with formulas, graphs and mathematical tables”, Dover Publications	1972
4.	Giordano N and Nakanishi H “Computational Physics”, Prentice Hall, 2nd Ed.	2006
5.	Pang T, “An Introduction to Computational Physics”, Cambridge Univ. Press	2006