Deccan Education Society's

FERGUSSON COLLEGE, PUNE

(AUTONOMOUS)

SYLLABUS FOR M. Sc. - II Physics

Semester III

Effective from Academic Year 2016

Preamble:

Fergusson College is awarded academic autonomy by the UGC beginning the year 2016-17. This autonomy is for a period of six years. We shall be following the semester pattern for academic transactions and the Credit Based Assessment System. The curriculum for the graduate programme in Physics is designed to cater to the requirements of the Autonomy and the Credit system following the UGC guidelines.

The Post graduate programme in Physics is spread over two years with two semesters per year.

The programme is aimed to be more learning centric than teaching centric. The courses are designed so that a student progressively develops a deeper understanding of various aspects of physics and at the end of the programme a student is a well trained with the basic understanding of physics as a discipline of science.

Emphasis will be given on practical based experience. Research component at the PG level is brought in through the projects students will be working on.

Continuous assessment is an integral part of the credit system. This will help students learn their subjects systematically and thoroughly.

Objectives:

1. To help student develop the scientific attitude and to understand various physical phenomena in nature.
2. To help student learn various mathematical and experimental tools used to study physical phenomena.
3. To help student develop analytical mind and face real world challenges.
4. To expose student to the latest developments in physics.
5. To develop an aptitude for research in physics.

Course Structure for M.Sc.-II - Physics

Semester	Course Code	Title of the Course
III	PHY5301	Experimental Techniques in Physics
	PHY5302	Vacuum Science and Technology
	* PHY5303	Physics of Nano Materials
	* PHY5304	Basic Material Science
	* PHY5305	Astronomy and Astrophysics - I
	* PHY5306	Atmospheric Science
	PHY5307	Physics Practical - V
	PHY5308	Physics Practical - VI
	PHY5309	Self Learning: Biomedical Instrumentation
	Students should select either PHY5303 & PHY5304 OR PHY5305 & PHY5306 for Semester III	
IV	PHY5401	Nuclear Physics
	PHY5402	Physics of Semiconductor Devices
	* PHY5403	Thin Film Physics and Technology
	* PHY5404	Materials Synthesis, Processing and Applications
	* PHY5405	Astronomy and Astrophysics - II
	* PHY5406	Instrumentation Techniques
	PHY5407	Physics Practical - VII
	PHY5408	Physics Practical - VIII
	PHY5409	Self Learning: General Relativity and Gravitation
	Students should select either PHY5403 & PHY5404 OR PHY5405 & PHY5406 for Semester IV	

Extra Credits for M.Sc.-II - Physics

Semester	Course Code	Title of the Course
III	XCS0007	Introduction to Cyber Security - III / Information Security - III
	XSD0008	Skill Development - III
IV	XCS0009	Introduction to Cyber Security - IV / Information Security - IV
	XSD0010	Skill Development - IV

PAPER CODE: PHY5301
PAPER – I: EXPERIMENTAL TECHNIQUES IN PHYSICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Sensors, Signals and Signal Analysis:** *Sensors*: Characteristics, classification, operating principles of sensors (electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV gas and humidity). *Signals*: random signals and time series (basic), Signal analysis: Time and frequency domain analysis, spectral analysis, auto and cross correlation functions. Measurement errors and analysis.	**12**
Unit - II	**Spectroscopic characterization**: (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), XPS, EDAX, Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR).	**12**
Unit - III	**Structural and Morphological Characterization:** Principle, Instrumentation and Working of *X-ray Diffraction*: Production of X-rays, Types (continuous and characteristics), Bragg's diffraction condition, principle, instrumentation (with mass absorption filters) and working, Techniques used for XRD – Laue's method, Rotating crystal method, Powder (Debye-Scherrer) method, Derivation of Scherrer formula for size determination. *Neutron Diffraction*: Principle, Instrumentation and Working. *Optical Microscopy*: Principle, Instrumentation and Working of optical microscope. *Electron Microscopy*: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM) –Advantages over SEM, Transmission Electron Microscope (TEM), Selected Area Electron Diffraction (SAED). *Probe Microscopy*: Scanning Tunnelling Microscope (STM) and Atomic Force Microscope (AFM).	**12**
Unit - IV	**Thermal analysis**: Thermo-gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Graphical analysis affecting various factors. *Magnetic Characterization*: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop**,** *SQUID Technique*: Principle, Instrumentation and Working.	**12**

References:

1. Instrumentation: Devices and Systems, C. S. Rangan, G. R. Sarma and V. S. V. Mani,Tata Mc. Graw Hill Publishing Co. Ltd.
2. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House
3. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
4. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt, J.A. Dean, CBS Publishers.
5. Elements of X-ray diffraction, Bernard Dennis Cullity, Stuart R. Stock, (Printice Hall)
6. Methods of Experimental Physics, Vol. II (R. V. Coleman, Academic Press, New York and London, 1974)

PAPER CODE: PHY5302
PAPER –II: VACUUM SCIENCE AND TECHNOLOGY
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Vacuum Science:** *Kinetic theory of gases*: Atomistic concept of gas pressure and temperature, Molecular distribution functions, Impingement rate of molecules on a surface, Free path of gas molecules, Gas viscosity and flow, gas conductance of a vacuum line, gas impedance of a vacuum line, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes.	**12**
Unit - II	**Production of Vacuum:** Meaning of vacuum and vacuum measuring units, vacuum ranges, pumping speed and pump down time. **Vacuum Pumps:** Mechanical pumps (Oil sealed rotary pump, Roots Pump, Molecular drag pump), Diffusion pump (Operating principles, back streaming, traps and baffles, performance ranges), Cryosorption pumps, Getter pumps (Chemical cleanup and sublimation pumps, Electrical cleanup and ion pumps, Evapour ion pumps, Sputter ion pumps, Titanium sublimation pump)	**12**
Unit - III	**Vacuum Measurements:** Measurement of low pressure Pressure gauges for low to high vacuum, Mc Leod manometer, Thermal conductivity gauges, Pressure gauges for high to ultrahigh vacuum, Hot cathode ionization gauges, Cold cathode ionization gauges, Operation of High-vacuum gauges.	**12**
Unit - IV	**Vacuum Applications:** Applications in science, technology, research, space science, medical science, day to day life. Use of vacuum in particle accelerators.	**12**

References:

1. *Hand book of Thin Film Technology*, L. I. Maissel and R. Glang, Mc Graw Hill Book Co. 1970, 07-039742-2
2. *Vacuum Physics and Techniques,* T. A. Delchar, Chapman and Hall.
3. *Vacuum Technology,* A. Roth, (North Holland, Elsevier Science B.V. 1990)
4. *High Vacuum Techniques,* J. Yarwood, (Chapman and Hall, London, 1967
5. Online resources can be used for reference.

PAPER CODE: PHY5303
PAPER – III: PHYSICS OF NANO MATERIALS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Quantum Size Effects:** Effect of reduction of dimensions, Quantum size effect. Particle in a box, density of states for a zero, one, two, and three dimensional box, Surface and interface effects, surface energy and surface curvature. Sintering, Ostwald ripening and Agglomeration. Electrostatic and Steric Stabilization. Introduction to nano-sized materials and structures.	**12**
Unit - II	**Synthesis of Nanomaterials:** High energy Ball Milling, Melt mixing, Physical Vapour Deposition, Cluster Beam Deposition, Sputter Deposition, Chemical Vapour Deposition. Homogeneous and Heterogeneous nucleation, Growth of nuclei controlled by diffusion and surface process. Synthesis of nanoparticles: Wet chemical method (colloidal route), Electrochemical Method, Langmuir-Blodgett method, Sol-gel method and Hydro thermal method, Radiation route.	**12**
Unit - III	**Special Nanomaterials:** Fullerene, Graphene, Types and Structures of Carbon nanotubes, Porous Silicon, Aerogels, Passivation of quantum dots by core-shell structures, Nano-composites.	**12**
Unit - IV	**Properties and Applications and (Future) of Nanomaterials:** Mechanical, Thermal, Electrical, Optical and Magnetic Properties. Surface Plasmon Resonance and Super-paramagnetism. Application to Nanoelectronics, Super capacitors, Quantum Dots and Quantum well devices, (QD sensitized solar cells and dye-sensitized Solar cells), Optical Devices, Medical, Biological, Automobiles (Engineering), Space, Defence, Sports and Cosmetics. Social and Ethical issues involved in applications of nanomaterials.	**12**

References:

1. *Nanotechnology: Principles and Practices.* Sulbha K. Kulkarni, Capital Pub.
2. *Nanostructures and Nanomaterials Synthesis, Properties & Applications*. Guozhong Cao, Imperials college Press London.
3. *Nanomaterials: Synthesis, Properties & Applications.* Edited by A. S. Edelstein & R. C. Commorata. Institute of Physics Publishing, Bristol & Philadelphia.
4. *Introduction to Nanotechnology*. C.P. Poole Jr. & F. J. Owens, Wiley Student Ed.
5. *Nano*: The Essentials. T. Pradeep, McGraw Hill Education.
6. *Nanotechnology: Fundamentals and applications by Manasi Karkare*, I. K. International Pvt. Ltd., New Delhi (2008).
7. *Properties of Semiconductor Nanocrystals* by S. V. Gaporenko (Cambridge Press), 1997.

PAPER CODE: PHY5304
PAPER –IV: BASIC MATERIAL SCIENCE
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Defects in Solids:** Elastic and inelastic behaviour, *Point defects*: vacancies, interstitials, Schottky defects and Frenkel defects, non-stoichiometry. *Line defects*: edge and screw dislocations. Properties of dislocations, force on dislocation, energy of dislocation, dislocation density, interaction between dislocations (cross-slip and climb), Frank-Read source, plastic deformation, motion of dislocation, creep. *Surface defects*: grain boundaries, stacking fault. Volume defect: twin boundary.	**12**
Unit - II	**Solid Solutions:** *Solid solubility*: types of solid solutions, factors governing solid solubility (Hume - Rothery rule), atomic size in solid solutions, size factor, Vegard's law, strain in dislocations, superlattices (Bragg-William theory).	**12**
Unit - III	**Metallurgical Thermodynamics:** Laws of thermodynamics, Auxiliary thermodynamic functions, Measurement of changes in enthalpy and entropy, Richard's rule, Trouton's rule, Chemical reaction equilibrium, Thermodynamic properties of solutions (mixing processes - Rault's law, activity coefficient, regular solution behaviour - Henry's law), Gibb's phase rule: proof, explanation and application to single (mono) component (H_2O) and binary phase diagram.	**12**
Unit - IV	**Phase diagrams:** Thermodynamic origin of phase diagrams, Lever rule, types of phase diagrams. Definition of maxima, minima, miscibility gap. Topology of binary phase diagrams (examples of eutectic, peritectic, monotectic, eutectoid, peritectoid, syntactic reaction, extension rule). Experimental determination of phase diagrams. *Discuss suitable examples wherever necessary.*	**12**

References:

1. Elements of Materials Science and Engineering (5^{th} edition), Lawrence H. Van Vlack, Addison- Wesley Publishing Co. ISBN: 0-201-08089-3
2. Materials Science and Engineering – A First Course (5^{th} edition), V.Raghvan. PHI Learning Pvt Ltd, New Delhi, ISBN: 978-81-203-2455-8
3. Physical Metallurgy (Part I) R.W.Cahn and P. Hassen, North Holland Physics Publishing, New York.
4. Materials Science, G. K. Narula, K. S. Narula and V. K. Gupta, Tata McGraw Hill Publishing Co. Ltd, New Delhi, ISNN: 0-07-451796-1
5. Materials Science and Metallurgy for Engineers, V. D. Kodgire and S. V. Kodgire, Everest Publishing House,, ISBN: 81-86314-008
6. Introduction to Materials science for engineers (6th edition)-J.F.Shaekelford and M. K. Murlidhara- Pearson Education.
7. Experiments in Materials Science – Prof. E.C. Subbarao. et.al.
8. Experiments in Materials Science – V. Raghvan

PAPER CODE: PHY5305
PAPER – III: Astronomy and Astrophysics - I
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Module 1: OVER VIEW OF THE UNIVERSE:** Qualitative description of interesting astronomical objects, (from planets to large scale structures), Length, Mass and Timescales, Physical conditions in different objects, Evolution of structures in the universe, red-shift. Radiation in different bands, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature, Celestial Sphere, Astronomical Coordinatte Systems, Measurement of Time.	**12**
Unit - II	**Module 2: THE SUN AND STELLAR STRUCTURE:** A. Solar Photosphere Solar Atmosphere, Chromosphere, Corona, Solar Activity, Basics of Solar Magneto, hydrodynamics Helioseismology. Solar System: Facts and Figures Origin of the Solar System: The Nebular Model Tidal Forces and Planetary rings. B. Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model Polytropic Stellar Model. Stellar Spectra and classification: Atomic Spectra Review, Stellar Spectra, Spectral Types and their Temperature Dependence, Black Body Approximation, H-R Diagram, Luminosity Classification.	**12**
Unit - III	**Module 3: STAR FORMATION, NUCLEOSYNTHESIS AND STELLAR EVOLUTION:** Basic Composition of Interstellar Medium, Interstellar Gas, Interstellar Dust Formation of Protostar, Jeans Criterion Fragmentation of Collapsing Clouds from Protostar to Pre-Main Sequence Hayashi Line, Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars, Evolution on the Main Sequence, Evolution beyond the Main Sequence, Supernovae. Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf, Chandrasekhar Limit, Neutron Star, Gravitational Red-shift of Neutron Star, Detection of Neutrons.	**12**
Unit - IV	**Module 4: GALAXIES**: Galaxy Morphology, Hubble's Classification of Galaxies, Milky Way Galaxy, Spiral and Elliptical galaxies, Galaxies as self gravitating systems; spiral structure, Supermassive black holes, Active galactic nuclei. Nature of Rotation of the Milky Way, Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms, Stars and Star Clusters of the Milky Way, Properties of and Around the Galactic Nucleus The Intrinsic Shapes of Ellipticals, de Vaucouleurs Law, Stars and Gas, Spiral and Lenticular Galaxies, Bulges, Disks, Galactic Halo. Active Galaxies Classification of the Active Galaxies, Some Emission	**12**

	Mechanisms Related to the Study of Active Galaxies, Behavior of Active Galaxies, Quasars and Radio Galaxies Seyferts, BL Lac Objects and Optically Violent Variables, The Nature of the Central Engine, Unified Model of the Various Active Galaxies.	
	***N. B.: Astronomy and Astrophysics - I syllabus is subject to slight modifications.**	

References:

1. Modern Astrophysics, B. W. Carroo and D. A. Ostlie, (Addison-Weseley).
2. The physical universe, F. Shu, (University Science books).
3. The Physics of Astrophysics, Volume I and II, F. Shu, (University Science books).
4. Theoretical Astophysics, Volumes I, II and III,
5. T. Padmanabhan, (Cambridge University Press)

PAPER CODE: PHY5306
PAPER –IV: Atmospheric Science
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Introduction to Earth's Atmosphere:** Atmospheric composition, Layers (Troposphere, Stratosphere, Mesosphere, Ionosphere, D, E, F-I, F-II), Thermodynamic structure of earth's atmosphere, Thermodynamic laws, Equation of state (Case of dry and moist air), Adiabatic, pseudo adiabatic and isothermal processes, Entropy, Potential temperature, Virtual temperature, Humidity parameters, Clausius-Clapeyron equation, Thermodynamic diagrams - general considerations, Emagram, Tephigram, Uses of thermodynamic diagrams, Thermodynamic instabilities, Hydrostatic equilibrium, Computation of scale-heights, Stability of atmosphere, Role of Convective Available Potential Energy (CAPE), Convective Inhibition Energy (CINE) in thunderstorm development.	**12**
Unit - II	**Interaction of Radiation with Atmosphere:** Black body radiation, Wein's law of displacement, Kirchhoff's law, Solar and terrestrial radiation, Implications of solar radiations to the earth's atmosphere, Polar lights, Scattering (Rayleigh and Mie), Radiation balance of earth's atmosphere, Green house effect.	**12**
Unit - III	**Upper Atmosphere:** Thermal structure of troposphere, Radio wave propagation, Effect of earth's curvature, Strato-sphere circulation and stratospheric warming, Quasi-Biennial oscillation, Ozone, Spatiotemporal variation of Ozone, Umkehr effect, Ozone depletion.	**12**
Unit - IV	**Cloud Physics:** Atmospheric aerosol, Condensed nuclei, Curvature and solute effect, Condensation, Growth of cloud droplets by diffusion, by collision and by coalescence, Collection efficiency, Freezing nuclei, Mechanism of growth of ice particles in cloud, Formation of ice, Rain making experiments. Thunderstorm and hail, Observational studies on cloud structure, Effect of wind shearing on cloud growth.	**12**

References:

1. Asnani G., 1993, Tropical Meteorology Vol I and II. Pune., Nobel Printers
2. Hess S. L., 1959, Introduction to Theoretical Meteorology. Holt; New York
3. Lal D. S., 2003, Climatology. Sharda Pustak Bhawan
4. Trewartha G. T., 1943, An Introduction to Weather and Climate. Mcgrow-Hill Book Company, Inc.; New York; London
5. Wallace J. M., Hobbs P. V., 2001, Atmosphere, Weather and Climate. Kisalaya Publications
6. Wallace J. M., Hobbs P. V., 2006, Atmospheric Science: An Introductory Survay, Vol. 92, Academic Press
7. Yau M. K., Rogers R., 1996, A Short Course in Cloud Physics. Elsevier

PAPER CODE: PHY5307
PAPER – V: Physics Practical - V
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Analysis of XRD of various structures
2	Analysis of FTIR spectrographs
3	Zeeman effect
4	Laser I
5	Laser II
6	Curie temperature of magnetic materials
7	Measurement of L , C, dielectric constant and Q
8	Variation of resistance with temperature and humidity – two probe method
9	Use of HYSPLIT model – computation of long range transport of Aerosols
10	Use of DREAM simulation model to compute Aerosols concentrations.
11	Radiation pattern of various antennas.
12	Determination of elements in the Sun using Fraunhoffer spectra

PAPER CODE: PHY5308
PAPER – VI: Physics Practical - VI
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Introduction to MATLAB
2	Plotting of graph using MATLAB
3	Lattice Vibrations
4	Equipotential contours and surfaces
5	Field distribution across biased and unbiased p-n junction
6	Potential distribution across biased and unbalanced p-n junction.
7	Optical absorption coefficient
8	Determination and visualization of Fermi level
9	Simple interfacing experiments using PLC
10	Design and built P-I controller (dc motor speed controller with tachometer feedback concept)
11	Design and built P-I-D controller (same application)
12	Design, build and test 4-20 mA current transmitter for an input of 0-10V using single ended power supply.

PAPER CODE: PHY 5309 **PAPER – VII: Self Learning: Biomedical Instrumentation:** **No. of Credits: 1** **No. of Lectures: 15**	
Brief outline of the course	
	Biomedical Instrumentation: Study of ECG, EEG, 2D, 3D echo techniques, CT Scan, MRI, X-ray and nuclear radiations, NMR systems and Ventilators. References: 1. Introduction to Biomedical Equipment Technology, Joseph J. Carr, John M. Brown, Pearson Education (Low price Indian edition), ISBN 10: 8178083272 / ISBN 13: 9788178083278 2. Principles of Applied Biomedical Instrumentation, Third edition, L. A. Geddes and L. E. Baker, Wiley India Pvt. Ltd., N. Delhi, ISBN: 978-81-265-1807-4 3. Bio-medical Electronics & Instrumentation, Prof. S. K. Venkata Ram, (Revised edition 2007), Galgotia Publications Pvt. Ltd., N. Delhi, ISBN: 81-7515-312-1

Additional courses for grade.

	PAPER CODE: XCS0007 **Name of the Course: Introduction to Cyber Security - III / Information Security - III** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XSD0008 **Name of the Course: Skill Development - III** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is designed to develop subject specific skills expected of a PG student. Example Scientific writing, preparing presentations

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SYLLABUS FOR M. Sc. - II Physics

Semester IV

Effective from Academic Year 2016

PAPER CODE: PHY5401
PAPER – I: NUCLEAR PHYSICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**General Properties and Concepts of Nuclei:** Nuclear Mass & Binding Energy, Measurement of Charge, Radius-Electron Scattering Experiment, Concept of Mass Spectrograph. Nuclear spin, Magnetic Dipole Moments & Electric Quadrupole Moments of Nuclei, Radioactivity, Unit of Radioactivity, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta Decay: Conditions for Spontaneous Emission of $ß^-$ & $ß^+$ Particles, Selection Rules, Origin of Beta Spectrum-Neutrino Hypothesis, Gamma Decay: Decay Scheme of ^{137}Cs & ^{60}Co Nuclei, Internal Conversion, Internal Pair Creation.	**12**
Unit - II	**Radiation Detectors and Nuclear Models:** Interaction of nuclear radiation (electron, neutron, gamma rays and ions) with matter, Radiation Detectors: NaI (Tl) Scintillation Detector, Si (Li) and Ge (Li) Detectors, High Purity Germanium Detector. Nuclear Models: Shell Model- Square Well Potential, Harmonic Oscillator Potential, Spin-Orbit Coupling, Predictions of the Shell Model, Achievements and Failures of shell Model, Fermi Gas Model, Collective Model.	**12**
Unit - III	**Reaction Dynamics, Nuclear Reactors and Accelerators:** Reaction Dynamics: Types of Nuclear Reactions, Conservation Laws in Nuclear Reactions, Q of Nuclear Reaction, Compound Nucleus Hypothesis, Gamma decay selection rules. Nuclear Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, List of Different Types of Reactors Developed in India. Accelerators: Van de Graff, Microtron, Cyclotron, Electron and Proton Synchrotron, Pelletron.	**12**
Unit - IV	**Nuclear Interactions and Particle Physics:** Nuclear Interactions: Low Energy Neutron-Proton Scattering, Scattering Length, Spin Dependence of neutron-proton Interaction, proton-proton and neutron-neutron Scattering at Low Energies. Particle Physics: Classification of Elementary Particles, Mass Spectra and Decays of Elementary Particles- Leptons and Hadrons, Quantum Numbers, Conservation Laws, Quarks.	**12**

References:

1. R. D. Evans, The Atomic Nucleus, Tata McGraw Hill.
2. I. Kaplan, 1989, Nuclear Physics, 2nd Edition, Narosa, New Delhi.
3. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill.
4. D. C. Tayal, Nuclear Physics, Himalaya Publishing House.
5. S. B. Patel, Nuclear Physics an Introduction, 2nd edition, New Age International Publishers.
6. S. N. Ghoshal, Atomic and Nuclear Physics, S. Chand.
7. E. Segre, Nuclei and Particles
8. K. S. Krane, 1988, Introductory Nuclear Physics, Wiley, India.
9. S. S. Kapoor and V. S. Ramamurthy, Nuclear Radiation Detectors, Wiley eastern Limited.

PAPER CODE: PHY5402
PAPER – II: PHYSICS OF SEMICONDUCTOR DEVICES
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Properties of Semiconductors:** Band structure of semiconductors, carrier concentration at thermal equilibrium for intrinsic and doped semiconductors, carrier energy distribution, application of Fermi factor to semiconductors, Density of available states, Excess carriers, Carrier transport phenomena (Mobility, Resistivity, Hall effect), Recombination process, Basic equation for semiconductor device operation.	**12**
Unit - II	**PN Junction:** Basic device technology, Depletion region and depletion capacitance, Current Voltage characteristics (Ideal case, Shockley Equation), Generation-recombination process, High injection condition, Diffusion capacitance, Narrow base diode, Junction breakdown.	**12**
Unit - III	**Junction Transistor & Field Effect Devices:** Formation of transistor, Basic Current-Voltage relationship, Current gain in transistor, Injection efficiency, Base transport factor, Depletion layer and surface recombination. Static characteristics (common base & common emitter configurations). Power transistor: General consideration, Second breakdown switching transistor, Uni-junction transistor Schottky diode, Semiconductor Controlled Rectifier, Junction Field Effect Transistor Basic characteristics: static characteristics, Dynamic characteristics, current limiter.	**12**
Unit - IV	**Metal Semiconductor & Metal Insulator Semiconductor Devices:** Schottky effect, Energy Band relation at metal semiconductor contact, Ideal condition and surface states depletion layer, General expression for barrier height, Current transport theory in Schottky barrier, Thermionic emission theory, Diffusion theory. Measurement of Schottky barrier height, current voltage measurement, forward characteristics, reverse characteristics. Metal semiconductor IMPATT Diode. Ideal MIS diode, surface states, surface charges and space charges, effects of metal work function.	**12**

References:

1. Physics Solid State Devices – Streetman B.B.
2. Physics of Semiconductor Devices – S.M. Sze
3. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley
4. Introduction to Semiconductor devices – K.J.M. Rao
5. Physics of Semiconductor Devices – Michael Shur
6. Semiconductor Physics – Smith

PAPER CODE: PHY5403
PAPER – III: THIN FILM PHYSICS AND TECHNOLOGY
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Thin Film Deposition Techniques and Thickness Measurement:** *Introduction*: brief discussion of the bulk and the thin film properties, *Physical Vapour Deposition Methods*: Evaporation – thermal, e-beam; Sputter Deposition - DC, RF, Microwave; Pulsed Laser, Plasma assisted deposition, Molecular Beam Epitaxy, *Chemical Vapour Deposition Methods*: CVD, MOCVD, Spray pyrolysis, coating, *Other Techniques*: Langmuir Blodgett, Self-Arrangement Monolayer, Dip coating and Spin Coating *Thickness Measurement Techniques*: Tolansky technique, Talystep (stylus) method, Quartz crystal microbalance, Stress measurement by optical method, Gravimetric method.	**12**
Unit - II	**Theories and models of thin film growth:** *Theories of thin film nucleation***:** Impingement, Adsorption and Thermal Accommodation, The Capillarity Model, The Atomistic Models, Structural Consequences of Thin Film Nucleation, The Four stages of film Growth, The Incorporation of Defects During Growth.	**12**
Unit - III	**Properties of thin films:** *Electrical Properties*: Source of Resistivity in Metallic conductors, Influence of thickness on the resistivity of thin films, Hall Effect & Magnetoresistance in thin films, Fuch-Sondhemir theory, TCR and its effects. *Mechanical properties*: Adhesion & its measurement with mechanical and nucleation methods, stress measurement by using optical method. *Optical properties*: Properties of Optical Film Materials, Thin Film Optics, Multilayer Optical Film Applications. Antireflection Coatings, Multilayer Films, Interference Filters, Polarizers.	**12**
Unit - IV	**Emerging Thin Film Materials and Applications:** Patterning techniques (Photolithography), Diamond Films, Thin film resistors, capacitors, Junction devices (Diodes, Transistors, Solar cells), ICs, Thin film sensors (gas and humidity), Thin films for information storage (Magnetic and optical recording), Metallurgical applications, Photo thermal converters, Optical coatings.	**12**

References:

1. *Hand book of Thin Film Technology*: L. I. Maissel and R. Glang, Mc Graw Hill Book Co. 1970, 07-039742-2
2. *Thin Film Phenomena*: K. L. Chopra, Mc Graw Hill Book Co. 1969
3. *Material Science of Thin Films*: M. Ohring, Academic Press, 1992, ISBN: 0-12-524990-X
4. *Thin Film Process*: J. L. Vossen and Kern, Academic Press, 1978

PAPER CODE: PHY5404
PAPER – IV: MATERIALS SYNTHESIS, PROCESSING AND APPLICATIONS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Diffusion in Solids:** Mechanism of Diffusion, Fick's first law of diffusion, Fick's second law of diffusion, solution to Fick's second law (error function), Atomic model of diffusion, Applications based on the second law, experimental determination of D, corrosion resistance of duralumin, decarburization of steel.	**12**
Unit - II	**Material Synthesis:** Materials Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science. Synthesis of Bulk materials: Metallic and non metallic materials, Ceramics and other materials. Basic concepts of powder technologies, compaction, sintering, calcination, phenomenon of particle coalescence, porosity, vitrification reactions.	**12**
Unit - III	**Material Processing**: Quenching: concept, glass formation, splat quenching. Processing of surface layers of solids : Ion beam processing, features of ion induced phenomenon, low induced phenomenon in materials, Laser processing: Laser types: CW and pulsed laser, various types of laser processing, concepts of laser annealing, alloying cladding and laser deposition with examples. Other methods: Sputtering and chemical CVD processing.	**12**
Unit - IV	**Applications of Materials** **Magnetic Materials:** Ferromagnetic materials, magnetic domains, hysteresis. Hard magnets and soft magnets. Origin of interaction in ferromagnetic material, rare earth garnets orthoferrites and Haemitite, Hexagonal ferrites. High Tc materials (Refractory materials), Giant magnetoresistance (GMR) materials (with brief discussion on magnetoresistance). Quasi crystals, optical materials, piezoelectric and ferroelectric material, nanoparticles.	**12**

References:

1. Elements of Materials Science and Engineering (5^{th} edition), Lawrence H. Van Vlack, Addison- Wesley Publishing Co. ISBN: 0-201-08089-3
2. Materials Science and Engineering – A First Course (5^{th} edition), V.Raghvan. PHI Learning Pvt Ltd, New Delhi, ISBN: 978-81-203-2455-8
3. Materials Science and Metallurgy for Engineers, V. D. Kodgire and S. V. Kodgire, Everest Publishing House,, ISBN: 81-86314-008
4. Materials Science, G. K. Narula, K. S. Narula and V. K. Gupta, Tata McGraw Hill Publishing Co. Ltd, New Delhi, ISNN: 0-07-451796-1
5. Physical Metallurgy (Part I) R.W.Cahn and P. Hassen, North Holland Physics Publishing, New York.
6. Introduction to Materials science for engineers (6th edition)-J. F.Shaekelford and M. K. Murlidhara- Pearson Education.
7. Experiments in Materials Science – Prof. E.C. Subbarao. et.al.
8. Experiments in Materials Science – V. Raghvan

PAPER CODE: PHY5405
PAPER –III: Astronomy and Astrophysics - II
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**Module 1: ASTROPHYSICS** A. Gravity: Newtonian gravity and basic potential theory, Simple orbits – Kepler's laws and precession, flat rotation curve of galaxies and implications for dark matter, virial theorem and simple applications, role of gravity in different astrophysical systems. B. Radiative Processes: Overview of radiation theory and Larmor formula, Different radiative processes: Thomson and Compton scattering, Bremsstrahlung, Synchrotron [detailed derivations are not expected] Radiative equilibrium, Planck spectrum and properties; line widths and transition rates in QT of radiation, qualitative description of which radiative processes contribute in which waveband/ astrophysical system, distribution function for photons and its moments, elementary notion of radiation transport through a slab, concept of opacities. C. Gas Dynamics: Equations of fluid dynamics; equation of state in different regimes [including degenerate systems]; Models for different systems in equilibrium, Application to White dwarfs / Neutron stars, Simple fluid flows including supersonic flow, example of SN explosions and its different phases.	**12**
Unit - II	**Module 2: LARGE SCALE STRUCTURES & THE EXPAND ING UNIVERSE:** Cosmic Distance Ladder. An Example from Terrestrial Physics Distance Measurement using Cepheid Variables Hubble's Law, Distance-Velocity Relation, Clusters of Galaxies, The Virial Theorem and Dark Matter, Friedmann Equation and its Solutions, Cosmology, Cosmological models, Early Universe and Nucleosynthesis, Cosmic Background Radiation, Evolving vs. Steady State Universe	**12**
Unit – III	**Module 3: COSMOLOGICAL MODELS:** Cosmological Principles, Robertson-Walker metric, cosmological redshift, Hubble's law, Observable quantities-luminosity and angular diameter distances. Dynamics of Friedmann-Robertson-Walker models. Solutions of Einstein's equations for closed, open and flat Universes. Physical Cosmology and the Early Universe: Thermal History of the Universe: Temperature - redshift relation, distribution functions in the early Universe-relativistic and non-relativistic limits. Decoupling of neutrinos and the relic neutrino background-Nucleosynthesis. Decoupling of matter and radiation; Cosmic microwave background radiation. Inflation-Origin and growth of Density Perturbations.	**12**
Unit - IV	**Module-4 : PRINCIPLES OF RELATIVITY:**	**12**

	Overview of Special Relativity, space-time diagrams, Introduction to general relativity (GR), equivalence principle, gravitation as a manifestation of the curvature of space-time. Geometrical Framework of General Relativity : Curved spaces, tensor algebra, Metric, affine connection, covariant derivatives, Physics in curved space-time, Curvature-Riemann tensor, Bianchi identities, Action Principle, Einstein's field equations, Energy momentum tensors, energy-momentum tensor for a perfect fluid, connection with Newton's theory. Solutions to Einstein's Equations and their Properties: Spherical symmetry, derivation of the Schwarzschild solution, test particle orbits for massive and massless particles. The three classical tests of GR, black holes, event horizon-one way membranes, Gravitational Waves.	
	***N. B.: Astronomy and Astrophysics - II syllabus is subject to slight modifications.**	

References:

1. General Relativity and Cosmology, J. V. Narlikar, (Macmillan company of India Ltd., Delhi).
2. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, (Pergamon Press, Oxford).
3. First course in general relativity, B. F. Schutz, (Cambridge University Press).
4. Introduction to Cosmology, J. V. Narlikar, (Cambridge University Press).

PAPER CODE: PHY5406
PAPER – IV: Instrumentation Techniques
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit - I	**METEOROLOGICAL INSTRUMENTATION and OBSERVATIONAL TECHNIQUES:** General principles of surface instrumental measurements, Conventional measurements of pressure, temperature, humidity, wind speed and direction, sunshine duration, radiation-shortwave and long wave, precipitation, visibility, clouds, soil temperature and soil moisture, evaporation ocean temperature, salinity, wave height, currents, Self recording instruments, Measurement control and data collection data loggers. Upper air pressure, temperature, humidity and wind measurements: - Pilot ballons, radiosonde, dropsonde, ozonesonde, radiometer sondes, GPS sonde. LIDARS, SODARS.	**12**
Unit - II	**RADAR and MODELLING** Introduction Radar basic principles, Electromagnetic waves,Radar Hardware, Radar equation for point targets, Distributed targets ,Doppler Velocity Measurements , Spectrum Width and turbulence, Meteorological Targets, Clear –Air Return, Meteorological uses of weather Radar Modeling: Definition of meso α, β, γ scale, Basic set of equations (for mesoscale meteorological simulations), Types of Models-Physical Models, Mathematical Models, Formulation of mesoscale numerical models. Assimilation and initialization of Atmospheric data for mesoscale modeling	**12**
Unit - III	**Astronomical Optics:** Reflecting, Refracting Telescopes, Schmidt Cassegrain, Spectrometers, Photometers, CCD's, Filters, Aberrations, Adaptiv Optics effects of Atmospheric turbulence, A. O. systems and components, correction of wave front distortion. Large mirrors and Telescope Arrays, interferometers, detectors and their characteristics, Signal to noise ratio and detection limits. Auxiliary optics for Telescopes.	**12**
Unit - IV	**Detectors and Instrumentation :** Radio telescopes Antennas, Receivers, Detectors / Mixers, Interferometers and aperture synthesis, The microwave background, COBE and WMAP Sub-millimeter detectors and instruments, Bolometers Thermal edge sensors, Microwave kinetic induction detectors Electronic imaging at ultraviolet, X-ray, and gamma-ray wavelengths. Introduction Grazing incidence telescopes Coded mask telescopes Ultraviolet detectors and instruments UV-sensitive CCDs Microchannel plates Electron-bombarded CCDs X-ray detectors and instruments CCDs in the X-ray regime X-ray spectroscopy X-ray instruments: the Chandra X-ray Observatory (CXO). Gamma rays Detectors for high energy Gamma-ray observatories.	**12**

References:

1. Probing the atmospheric boundary layer - D. H. Lenschow
2. Instruments and techniques for probing the atmospheric boundary layer –D.H.Lenchow
3. Guide to Meteorological Instruments and methods of observation WMO-8
4. Meteorological Instruments –W.E.K. Middleton and A.F.Spilhaus
5. Applicatios of Remote Sensing to Agrometeorology-F.Toselli, Kluwer
6. Mesoscale Meteorological Modelling – Roger A . Pielke
7. Mesoscale Atmosphric Circulation –B.W. Atkinson
8. Mesoscale Meteorology and Forcasts edited- P. S.Ray
9. Astronomical Optics, Daniel J. Schroeder, Acsdemic Press.
10. Telescopes and Techniques, C. R. Kitchin, (Springer).
11. Observational Astrophysics, R. C. Smith, (Cambridge University Pres).
12. Detection of Light : from the Ultraviolet to the Submillimeter, G. H. Rieke, (Cambridge University Press).
13. Astronomical Observations, G. Walker, (Cambridge University Press).
14. Astronomical Photometry, A. A. Henden & R. H. Kaitchuk, (Willmann-Bell).
15. Electronic Imaging in Astronomy, I. S. McLean, (Wiley-Praxis).
16. An introduction to radio astronomy, B. F. Burke & Francis, Graham-Smith, (Cambridge University Press).
17. Radio Astronomy, John D. Kraus, (Cygnus-Quasar Books).

PAPER CODE: PHY5407
PAPER – V: Physics Practical - VII:
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Synthesis of CdS nano particles by chemical method
2	Synthesis of nano particles by sol gel method.
3	Deposition of Thin / Thick film by spin coating / screen printing technique.
4	Determination of thin films by electrodeposition method.
5	Measurement of thickness of thin film by Tolansky method.
6	Phase transition temperature of binary liquid crystal mixture.
7	Characteristics of photo emissive (LED) photo conducting (LDR) and Photoelectric (Photocell) materials and devices.
8	Thermoelectric properties of materials
9	Study of Aerosols properties using Radiometer.
10	Measurement of total Ozone using ozonometer.
11	Characteristics of CCD camera
12	Measurement of Solar limb darkening effect

PAPER CODE: PHY5408
PAPER – VI: Physics Practical - VIII - PROJECTS
No. of Credits: 4 **No. of experiments: 12**

PAPER CODE: PHY5409
PAPER –VII: Self Learning: General Relativity and Gravitation:
No. of Credits: 1 **No. of Lectures: 15**

	Brief outline of the course
	General Relativity and Gravitation: GR: Riemannian Geometry, curvature of space time, principle of equivalence, Einstein field equations, Symmetries, asymptotic flatness, solar system and binary pulsar tests, Gravitation: Action and gravitational field equations, weak field limit, Schwarzschild solution, gravitational waves, propagation models of gravitation waves gravitational waves in flat and curved space time , gravitational wave detection properties of gravitational waves. References: 1. Gravitation Foundations and Frontiers, T. Padmanabhan, Cambridge University Press, ISBN-13 978-0-511-67553-9 (eBook (NetLibrary)), ISBN-13 978-0-521-88223-1 (Hardback) 2. An Introduction to Cosmology, J. U. Narlikar, Cambridge University Press

Additional courses for grade.

	PAPER CODE: XCS0009 **Name of the Course: Introduction to Cyber Security - IV / Information Security - IV** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XSD0010 **Name of the Course: Skill Development - IV** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is designed to develop subject specific skills expected of a PG student. Example Scientific writing, preparing presentations