St. Xavier's College – Autonomous
Mumbai

Syllabus
For 6th Semester Courses in PHYSICS
(June 2018 onwards)

Contents:

T.Y. B.Sc. PHYSICS **Course: S.PHY0601**
MODERN ASTROPHYSICS
No of Lectures: 60
This course is designed to understand and appreciate the diverse and fascinating nature of the field of astrophysics.
Learning Objectives:

1. Determination of positions of celestial objects and their distance, physical properties of these objects such as size, mass, temperature and brightness.
2. Stellar interior, stellar atmosphere and formation of stars.
3. Study of processes which lead to stellar evolution and its end states – white dwarf, pulsar or a black hole.
4. Study of Cosmology, expansion of the universe and the early universe. Nature of galaxies and structure of the universe.

UNIT I: TOOLS OF ASTRNOMY AND THE NATURE OF STARS (15 Lectures)
The Celestial Sphere, Coordinate systems, Kepler's Laws, The Virial Theorem;
Stellar Parallax, The Magnitude Scale, Blackbody Radiation, The Color Index;
The Relativistic Doppler Shift;
Spectral Lines;
Telescopes (Optical, Radio, Infrared, Ultraviolet, X-ray, and Gamma-Ray) (Self Study)
All-Sky Surveys and Virtual Observatories;
Binary Systems and Stellar Parameters;
The Classification of Stellar Spectra - The Formation of Spectral Lines, The Hertzsprung–Russell Diagram;

UNIT II: STELLAR STRUCTURE AND INTERSTELLAR MEDIUM (15 Lectures)
Stellar Atmospheres: The Description of the Radiation Field, Stellar Opacity, Radiative Transfer, The Transfer Equation, The Profiles of Spectral Lines;
The Interiors of Stars: Hydrostatic Equilibrium, Pressure Equation of State, Stellar Energy Sources, Energy Transport and Thermodynamics, Stellar Model Building, The Main Sequence;
The Sun: The Solar Interior, The Solar Atmosphere, The Solar Cycle;
The Interstellar Medium and Star Formation: Interstellar Dust and Gas, The Formation of Proto-stars, Pre-Main-Sequence Evolution;

UNIT III: STELLAR EVOLUTION AND END STATES OF STARS (15 Lectures)
Main Sequence and Post-Main-Sequence Stellar Evolution: Evolution on the Main Sequence, Late Stages of Stellar Evolution, Stellar Clusters;
Stellar Pulsation: Observations of Pulsating Stars, The Physics of Stellar Pulsation (Self-study)
The Fate of Massive Stars: Post-Main-Sequence Evolution of Massive Stars, The Classification of Supernovae, Core-Collapse Supernovae, Gamma-Ray Bursts, Cosmic Rays;
The Degenerate Remnants of Stars: White Dwarfs, The Chandrasekhar Limit, Neutron Stars, Pulsars;
The Black Holes: General Theory of Relativity and Black Holes

UNIT IV: GALAXIES AND COSMOLOGY (15 Lectures)

The Nature of Galaxies: The Hubble Sequence, Spiral and Irregular Galaxies, Elliptical Galaxies;
The Milky Way Galaxy: The Morphology of the Galaxy, The Kinematics of the Milky Way, The Galactic Center;
The Structure of the Universe: The Extragalactic Distance Scale, The Expansion of the Universe, Clusters of Galaxies;
Cosmology and The Early Universe: Newtonian Cosmology, The Cosmic Microwave Background, Relativistic Cosmology, Observational Cosmology; The Very Early Universe and Inflation, The Origin of Structure;

REFERENCES:

1. **An Introduction to Modern Astrophysics, Second Edition, By Carroll B.W., Ostlie D.A., Pearson Addison Wesley.**
2. **Shu, Frank H: The physical universe: an introduction to astronomy. Sausalito University Science Books ,1982 . - xi+584p : Hb. 0-935702-05-9 (520/SHU)**
3. **Astrophysics for physicists By Arnab Rai Choudhuri, Cambridge University Press.**

CIA: FIELD TRIP/ ARTICLE REVIEW / ASSIGNMENTS

T.Y.B.Sc.: Physics **COURSE: S.PHY0602**
Title: Electrodynamics
Number of Lectures: 60

Learning objectives: To understand the fundamentals and applications of classical electrodynamics

UNIT-I **(15 LECTURES)**

1. Dirac Delta function: The divergence of $\hat{r}/r^2$, one and three dimensional Dirac Delta function.
2. The Theory of Vector fields: The Helmholtz theorem, potentials.
3. Electrostatics: Divergence and curl of electrostatic fields, Electric Potential: Poisson's Equation and Laplace's Equation, potential of a localized charge distribution, Electrostatic boundary conditions. Work and Energy in Electrostatics: Work done to move a charge, the energy of a point charge distribution, the energy of continuous charge distribution, comments on Electrostatic Energy.
4. Laplace's equation in one dimension, Laplace's equation in two and three dimensions (self-study). Boundary conditions and Uniqueness theorems (without proof), conductors and second Uniqueness theorem. The classic image problem, Induced surface charge, force and energy.
5. Multipole Expansion: Approximate Potential at large distances, Monopole and Dipole terms, Origin of coordinates in Multipole Expansion, Electric field of a dipole.
6. Dielectrics, Induced Dipoles, Alignment of polar molecules, Polarization, Bound charges and their physical interpretation, Gauss' law in presence of dielectrics. A deceptive parallel, Susceptibility, Permittivity, Dielectric constant, Energy in dielectric systems, Forces on Dielectrics.

UNIT-II **(15 LECTURES)**

1. Straight line Currents, Divergence and Curl of B, Applications of Ampere's Law (Self-study), Magnetic Vector potentials, Magnetostatic Boundary conditions, Multipole Expansion of Magnetic Vector potential.
2. Diamagnets, Paramagnets and Ferromagnets, Magnetization, Bound currents and their physical Interpretation, Ampere's law in magnetized materials, A deceptive parallel, Magnetic susceptibility and permeability, Ferromagnetism.
3. Electrodynamics before Maxwell, Maxwell's correction to Ampere's law, Maxwell's equations, Magnetic charge, Maxwell's equations in matter, Boundary conditions.
4. Newton's third law in Electrodynamics, Maxwell's Stress Tensor, Conservation of Momentum, Angular momentum.

UNIT-III **(15 LECTURES)**

1. The wave equation for **E** and **B**, Monochromatic Plane waves, Energy and momentum in electromagnetic waves, Propagation in linear media, Reflection and transmission of EM waves at normal and oblique incidence, EM waves in conductor, Reflection at a conducting surface, the frequency dependence of Permittivity, Wave guides, TE waves in a Rectangular Wave Guide.
2. Potentials and Fields: The potential formulation, Scaler and vector potentials, Gauge transformations, Coulomb gauge and Lorentz gauge. Retarded Potentials, Jefimenko's Equations, Lienard-Wiechert Potentials, The Fields of a moving Point Charge.

UNIT-IV **(15 LECTURES)**

1. Dipole radiation: Electric and Magnetic dipole radiation, Radiation from arbitrary Source, Power radiated by point charge, Radiation reaction and its physical basis.
2. Relativity and electrodynamics: Magnetism as a relativistic phenomenon, How the field transform, The Field tensor, Electrodynamics in tensor Notation, Relativistic Potentials.

Reference:-

1. **Griffiths, David J.: Introduction to electrodynamics. 4th ed. Noida, Pearson India Education Services Pvt. Ltd, 2016 . - 603p. 978-93-325-5044-5 (537.64/GRI)**

Additional References:-

3. Capri, A.Z.; Panat, P.V.: Introduction to electrodynamics, New Delhi Narosa Publishing House, 2002 . - xvii+465p : Pb . - 81-7319-329-0
4. (537/CAP/PAN/059185)
5. Hayt, William H., Jr. Buck, John A.: Engineering electromagnetics 6th Ed. New Delhi Tata McGraw-Hill Publishing Company Limited 2001 . - xiii+561p : Pb . - 0-07-044580-X (537/HAY/BUC/060503)
6. Electricity and Magnetism - Navina Wadhwani
7. Introduction to electromagnetic fields and waves
8. Corson, Dale R.; Lorrain, Paul: Introduction to electromagnetic fields and waves. Indian reprint Bombay D.B. Taraporevala Sons & Co. 1962(1970) . - xiv+552p : Hb. (537.12/COR/LOR/032247)

1. **Purcell, Edward Mills: Electricity and magnetism. New York, McGraw-Hill Book Company 1965 . - xviii**+459p ; Berkeley Physics Course Vol. 2 .(530/BER)

CIA: FIELD TRIP/PROBLEM SOLVING/ARTICLE REVIEW / ASSIGNMENTS

T.Y.B.Sc. PHYSICS **COURSE:S.PHY0603**
Title:NUCLEAR PHYSICS
No of Lectures:60

Learning Objectives:-To Understand the constituents of the nucleus, their properties,detection and reactions.

UNIT-I: **(15 LECTURES)**

Properties of the nucleus: Rutherford scattering & measurement of nuclear size,Measurement of nuclear-radius by Hofstadter experiment.

The Q equation:- Types of nuclear reactions, the balance of mass and energy in nuclearreaction , the Q equation and solution of Q equation.

Radioactive decay: Decay chains.**Alpha decay :** Range of alpha particles, Disintegrationenergy, Alpha decay paradox: Barrier Penetration, Gamow's theory of alpha decay and Geiger-Nuttal law. Velocity and energy, Absorption of alpha particles: Range, Ionization and stopping power, energetics, energy levels & decay schemes. **Beta decay:** Introduction, Continuous beta ray spectrum-Difficulties encountered to understand it, Pauli's neutrino hypothesis, Velocity and energy of beta particles, energetics, energy levels and decay schemes. **Gamma decay:** internal conversion, nuclear isomerism.

UNIT-II **(15 LECTURES)**

Binding Energy and Mass formula: (Review of Liquid drop model &Weizsacher's semi-empirical mass formula), Mass parabolas - Prediction of stability against beta decay for members of an isobaric family, Stability limits against spontaneous fission. Qualitative predictions of shell model & Magic numbers.

Nuclear energy : Introduction, Asymmetric fission - Mass yield, Emission of delayed neutrons, energy release in fission, Nature of fission fragments, Energy released in the fission of U^{235}, Fission chain reaction, Fusion of lighter nuclei, Neutron cycle in a thermal nuclear reactor (Four Factor Formula), Comparison of fission and fusion processes.

UNIT-III **(15 LECTURES)**

Applications of nuclear energy :- nuclear reactors:- pressurized water reactors, boilingwater reactors, breeder reactors, fusion reactors.**Nuclear detectors**:- Ionization chamber, Proportional counter, G.M. Counter, Scintillation counter, Solid State detectors , Cloud and Bubble chamber, **Mossbauer effect, Detection of neutrino**, nuclear power generation, nuclear safety and hazards.

UNIT-IV **(15 LECTURES)**

Nuclear forces and their properties, Meson theory of nuclear forces, Yukawa Potential.Deuterium problem (only qualitative discussion).

Accelerators:-Introduction, the LINAC, cyclotron, synchrocyclotron, betatron synchrotron,proton synchrotron, Electrostatic Accelerator.

Elementary particles : Introduction, Classification of elementary particles based onconservation laws, particles and antiparticles, The Fundamental interactions, elementary particle quantum numbers, conservation laws and symmetry, quark model,.

References:

1. **Patel, S.B. : Nuclear physics : an introduction, 2nd ed. New Delhi New Age International (P) Ltd. 2011(2012) . - xiii+372p . - 978-81-224-3045-5 (539/PAT)**
2. **Kaplan, Irving : Nuclear physics, 2nd ed. Indian reprint New Delhi Narosa Publishing House 1963(1987) . - xiv+770p : - 81-85015-89-9 (539.7/ KAP)**
3. **Ghoshal, S.N. : Nuclear physics. New Delhi, S. Chand & Company Ltd. 2015 . - xvi+845p. 978-81-219-0413-1 (539.7/ GHO)**

Additional References.

1. **Segre, Emilio: Nuclei and particles : an introduction to nuclear and subnuclear physics Massachusetts W.A. Benjamin, Inc. 1965(1974) . - xvi+741p . - 0-8053-8600-9(539.7/SEG)**
2. **Beiser, Arthur; Mahajan, Shobhit; RaiChoudhury, S.: Concepts of modern physics. 7th ed. New Delhi McGraw Hill Education (India) Private Limited 2015 . - xxiii+623p. 978-93-513-4185-7 ; Pb.(539/BEI)**
3. **Tayal, D.C.: Nuclear physics. 5th ed. Mumbai, Himalaya Publishing House Pvt. Ltd. 2012 . - 783p. 978-93-5051-811-3 ; Pb. (539/TAY)**
4. **Murugeshan, R.; Sivaprasath, Kiruthiga: Modern Physics. 17th ed. New Delhi, S. Chand & Company Ltd. 2013 . - xvi+1040p 81-219-2801-X ; Pb. (530 MUR/SIV)**
5. **Kakani, S.L.; Kakani, Shubhra: Nuclear and particle physics. New Delhi, Viva Books Private Limited 2008 . - viii+965p 81-309-0040-8 ; Pb (539/ KAK/KAK)**

CIA: FIELD TRIP/PROBLEM SOLVING/REVIEW PAPER / ASSIGNMENTS

T.Y.B.Sc. PHYSICS **COURSE: SPHY0604**
Title:Solid State Physics
No of Lectures:60

Learning objective: To understand the fundamental properties of materials and devices

UNIT I **(15 lectures)**

Crystal physics: Introduction, lattice, basis, crystal structure, unit cell & primitive cell,crystal classes & crystal systems in two & three dimensions, Bravais lattices, atomic packing factors in cubic system and hexagonal lattice. Crystal structures of diamond, ZnS, Nacl, CsCl, Miller indices, Inter-planar spacing, Reciprocal lattice, Experimental diffraction methods, Brillouin zones .

UNIT – II **(15 lectures)**

Electrical and Thermal properties of Solids: Classical free electron theory of metals, Relaxation time, Collision timeand mean free path, Drawbacks of classical theory, Quantum theory of free electrons, Fermi-Dirac statistics and electronic distribution in solids, Density of energy states and Fermi energy, The Fermi distribution function, Heat capacity of the electron gas, Mean energy of electron gas at 0 K, Electrical conductivity from quantum mechanical considerations, thermionic emission, Lattice specific heat, Delong and Petit law, Einstein's theory of specific heat, Debye's theory

UNIT – III **(15 lectures)**

Band theory of solids: The Kronig- Penney model Brillouin zones, Number of wavefunctions in a band, Motion of electrons in a one-dimensional periodic potential, Distinction between metals, insulators and intrinsic semiconductors.

Band theory of Semiconductors: Electrons and Holes in an Intrinsic Semiconductor,Conductivity, Carrier concentrations, Donor and Acceptor impurities, Charge densities in a Semiconductor, Fermi level in extrinsic semiconductors, Diffusion, Carrier lifetime, The continuity equation.

UNIT – IV **(15 lectures)**

Magnetic properties of Matter: Diamagnetism and Paramagnetism, The origin ofpermanent magnetic dipoles, Diamagnetism and Larmor precession, The static paramagnetic susceptibility. Quantum mechanical theory of paramagnetism, Ferromagnetism- the Weiss molecular field, Comparison of the Weiss theory with experiment, the Weiss field, the anisotropy energy, the Bloch wall, coercive force and hysteresis.

Superconductivity : Concept , achievement at low temp, Meissner effect, Type1 and Type2 superconductors , Applications.

References:-

1. **Pillai, S.O. : Solid state physics 3rd ed. New Delhi, New Age International (P) Ltd. 1999 . - xx+676p . - 81-224-1190-8 (530.41/PIL)**

Additional References :

1. **Kittel, Charles: Introduction to solid state physics 8th ed. Reprint New Delhi Wiley India Pvt. Ltd. 2005(2015) . - xix+680p. 978-81-265-3518-7 ;(530.41/KIT)**

2. **Dekker, Adrianus J.: Solid state physics. Indian Reprint Delhi Macmillan Publishers India Ltd. 1957(2014) . - xiv+540p. 978-0333-91833-3 ; (530.41/DEK)**
3. **Solid State Physics - S.P.Kakani and Amit Kakani**

CIA: FIELD TRIP/PROBLEM SOLVING/ASSIGNMENTS / REVIEW PAPER

TYBSc PHYSICS **Course code: SPHY06PR**

Group1

1. Resolving power of a telescope.
2. Estimate distance to an object (and hence stars) using parallax method.
3. Observation of emission, continuous and absorption spectra. (Mercury, sodium or iodine spectra could be obtained.)
4. To determine the temperature of an artificial star.
5. To observe the Fraunhofer lines in sunlight and determine the elements present.
6. To study thermal emission of stars using color index U-G and G-R values from SDSS data.
7. To measure cosmological redshift of a given galaxy. (Compare with lab Hydrogen spectrum).
8. The measurement of the expansion of the Universe and the Hubble's constant using SDSS data.

Note: Expt 2 and 3 could be combined. Expt 5 -8 will include data analysis using Astronomical databases available for public use.

Group2

1. Mutual inductance
2. Measurements of curl and gradient
3. Hysteresis
4. Reflection and Transmission of EM waves
5. Orthogonal nature of EM waves
6. Impedance of coaxial cable
7. LC lumped element model of a transmission line.
8. Computer simulations in ED

Group3

1.Muon detection.
2.Absorption of alpha particles by materials of different thicknesses
3. Comparison of CeriumBromide and high purity detectors using Gamma ray radioactive source.
4. Data analysis in Scintillation detectors
5. Data analysis in Geiger Muller counter

Note:- *Experiments 1, 2 and 3 will be performed by students in TIFR .*

Group4

6.Energy band gap in semiconductor.
7.Fermi Energy in metals
8. Hall effect- Determination of Hall coefficient.
9. Analysis of X- Ray Diffraction data.
10.Semiconductor as a Temperature Sensor.

References:

1. **Chattopadhyay, D.; Rakshit, P.C.: An advanced course in practical physics. 8th ed.reprint Kolkata New Central Book Agency (P) Ltd. 2007(2009) . - xvi+860p : 81-7381-054-0 (530.078/ CHA/RAK)**
2. **Singh, Harnam: B.Sc. practical physics Reprint New Delhi S. Chand & Company Ltd. 1957(2008) . - xvi+498p : 81-219-0469-2 (530.76/SIN)**
3. **Ghosh, Samir Kumar: A textbook of practical physics 4th ed. Kolkata, New Central Book Agency (P) Ltd. 2005 . - xxii+389p : 81-7381-160-1 (530.078/GHO)**
4. **Arora, C.L.: B.Sc. practical physics, 19th ed. Reprint New Delhi S. Chand & Company Ltd. 1995(2010) . - xiv+693p : 81-219-0909-0 (530.0724/ARO)**
5. **Squires, G.L.: Practical physics 4th Ed. Cambridge Cambridge University Press 2001 . - xi+212p : Pb . - 0-521-77940-5 (530.0724/SQU)**
6. **Tayal, D.C. ed. by Ila Agarawal: University practical physics. Mumbai, Himalaya Publishing House Pvt. Ltd. 2000 . - xiv+548p : 81-7493-903-2 (530.0724/ TAY)**
7. **Worsnop, B.L.; Flint, H.T.: Advanced practical physics for students. 9th ed. Reprint. Bombay, Asia Publishing House, 1951(1971) . - vii+754p : (530.0724/WOR/FLI)**

TYBSc Physics: Applied Component **COURSE:SPHY06AC**

ENVIRONMENTAL PHYSICS **[60 LECTURES]**

Learning objective: To understand the Physics involved in Environmental processes

UNIT I **(15 LECTURES)**

Introduction to Basic environmental physics -1

Environmental physics: processes and issues
The human environment
The built environment
The urban environment
Energy for living
The Sun and the atmosphere
Observing the Earth's weather
Global weather patterns and climate

UNIT II **(15 LECTURES)**

Introduction to Basic environmental physics -2

Physics and soils
Vegetation growth and the carbon balance
Environmental issues for the twenty-first century

Basic Research Methodology

UNIT III **(15 LECTURES)**

Preparation of project proposal / Synopsis
Approval of final projects

UNIT –IV **(15 LECTURES)**

Analysis of data and discussion
Thesis writing (10000 -15000 words)

REFERENCES:

1) **Introduction to Environmental Physics, Planet Earth, Life and Climate**
Nigel Mason, Peter Hughes; TAYLOR AND FRANCIS PUBLISHERS
2) Newspapers, Magazines, Internet

PRACTICAL COURSE: SPHY06PRAC

The approved experimental work of dissertation will be conducted in the department lab or any other lab or in the field. It will be evaluated for 50 marks.

Evaluation Of Theory

1) CIA 1. 20-mark written exam.
2) CIA 2. Progress reports (20 mark)
3) End semester: Viva by internal and external examiners. (60 Marks)

There won't be any written end semester examination.