Department of Physics

Digboi College (Autonomous), Digboi – 786171, Assam, India

Syllabus for M.Sc. in Physics (CBCS)

Approved by the Meeting of the Board of Studies in Physics held on 17-06-2025.

Course Structure (Physics)

Details of courses under M.Sc.

Course	***Credits** Theory /Practical
I. Core Course **(12 Papers of 4 credits each)**	12X4=48
II. Discipline Specific Elective Course **(Minimum 5 Papers of 4 credits each)**	5X4=20
III. Ability Enhancement Courses (AEC) **(2 Papers of 2 credits each)**	2 X 2=4
IV. Generic Elective (GE) **(2 Papers of 4 credits each)**	4X2=8
Total credit (Minimum)	**80**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

** Optional dissertation or project work for additional 2 credits in semester III.

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM

M. SC. IN PHYSICS

	Papers			
	CORE Papers (4 Credits each)	DSE (Minimum one for Sem I, one for Sem II, one for Sem III and two for Sem IV) (4 Credits each)	GE (Minimum one in Sem II one in Sem III) (4 Credits each)	AEC (AECC/SEC) (Minimum one in sem I and one in sem III) (2 Credits each)
Sem-I	Mathematical Physics	DSE I		AEC I
Sem-I	Classical Mechanics			
Sem-I	Quantum Mechanics-I			
Sem-II	Quantum Mechanics-II	DSE II	GE-I	
Sem-II	Condensed Matter Physics			
Sem-II	General Lab-I			
Sem-III	Electrodynamics	DSE III	GE-II	AEC II
Sem-III	Atomic & Molecular Physics			Dissertation (additional)
Sem-III	General Lab-II			
Sem-IV	Nuclear Physics	DSE IV		
Sem-IV	Statistical Mechanics	DSE V		
Sem-IV	Plasma Physics			

* Student can opt for Dissertation (Credits 2) as an additional paper in 3rd semester.

** In semester IV a student opting for a particular DSE (except HEP), he/she is advised to opt for the corresponding lab paper. For HEP students, they are advised to opt for both HEP II and III.

*** The students are advised to consult the student advisor while opting for DSEs and GEs.

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Core course-I	Mathematical Physics	4
	Core Course-II	Classical Mechanics	4
	Core course-III	Quantum Mechanics-I	4
	Discipline Specific Elective –I	DSE I	4
	Ability Enhancement Course – I	AEC I	2
II	Core course-IV	Quantum Mechanics-I	4
	Core course-V	Condensed Matter Physics (Core)	4
	Core course-VI	General Lab-I	4
	Discipline Specific Elective –II	DSE II	4
	Generic Elective – I	GE I	4
III	Core course-VII	Electrodynamics	4
	Core Course-VIII	Atomic & Molecular Physics	4
	Core course-IX	General Lab-II	4
	Discipline Specific Elective –III	DSE III	4
	Generic Elective – II	GE II	4
	Ability Enhancement Course – II	AEC II	2
	Additional AEC	Dissertation	2
IV	Core course-X	Nuclear Physics	4
	Core course-XI	Statistical Mechanics	4
	Core course-XII	Plasma Physics	4
	Discipline Specific Elective –IV	DSE IV	4
	Discipline Specific Elective –V	DSE V	4

*** Additional AEC: Dissertation (credits 2) is an additional credit paper in semester III.

Core Papers (C): (Credit: 04 each)

1. Mathematical Physics (4)
2. Classical Mechanics (4)
3. Quantum Mechanics-I (4)
4. Quantum Mechanics-II (4)
5. Condensed Matter Physics (4)
6. General Lab-I (4)
7. Electrodynamics (4)
8. Atomic & Molecular Physics (4)
9. General Lab-II (4)
10. Nuclear Physics (4)
11. Statistical Mechanics (4)
12. Plasma Physics (4)

Discipline Specific Elective Papers (DSE): (Credit: 04 each)
(Minimum 5 papers to be selected)- DSE I to V

DSE I (Minimum one):

A. Electronics
B. Advanced Mathematical Physics

DSE II (Minimum one):

A. Theory of Relativity
B. Numerical Methods and Programming

DSE III: (Minimum one)

A. High Energy Physics I
B. Condensed Matter Physics I
C. Digital and Optical Electronics
D. Atmospheric Physics
E. Astrophysics and Cosmology I
F. Physics of Black Holes

DSE IV: (Minimum one)

A. High Energy Physics II
B. Condensed Matter Physics II
C. Communication Electronics
D. Space Physics
E. Astrophysics and Cosmology II
F. String Theory

DSE V: (Minimum one)

A. High Energy Physics III
B. Condensed Matter Physics lab
C. Electronics Lab
D. Space Physics Lab
E. Project/Dissertation

Generic Elective (Minimum 2 papers of 4 credits each)-GE I to GE II

A. Basic Quantum Mechanics
B. Foundation of Electronics
C. Fundamentals of Material Science
D. Thermal Physics
E. Classical Mechanics
F. Meteorology

Ability Enhancement Course (AEC): (Minimum 2 papers of 2 credits each)

A. Experimental Techniques
B. Observational Astronomy
C. Nano Structured Materials
D. Vacuum Technique
E. Meteorology

Additional AEC: (2 credits)

Dissertation

ABBREVIATIONS:

L: Lecture, T: Tutorial

CORE COURSES

Course Code: PH-C-I
Course Title: Mathematical Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-3, Tutorial-1

(1) To impart the knowledge of vector spaces and matrices that is relevant to the study of quantum mechanics.
(2) To develop the working knowledge on partial differential equations (homogeneous and inhomogeneous).
(3) To familiarize the learners with the basics of group theory and properties of Lie groups.
(4) To familiarize the learners with the basics of tensor analysis and to introduce important topics specifically relevant to the theory of relativity.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Linear Vector Spaces and Matrices (L 14, T 8, Marks 22)
Linear vector spaces- definition and examples, linear independence, basis and dimension, inner product, norm of a vector, orthonormal basis, Gram-Schmidt orthogonalization method, Schwarz's and Bessel's inequalities; linear operators, matrix representation of linear operators; special types of matrices- symmetric and antisymmetric, orthogonal, Hermitian and anti-Hermitian, unitary, normal; eigenvalues and eigenvectors; change of basis, similarity transformation, orthogonal and unitary transformations, diagonalization of matrices; infinite dimensional vector spaces, Hilbert space.

Unit II: Partial Differential equations (L 9, T 5, Marks 14)
Partial differential equations, method of separation of variables in cartesian, spherical and cylindrical coordinate systems, Laplace's equation, Poisson's equation, diffusion equation, examples of boundary value problems in physics; inhomogeneous differential equations and Green's function.

Unit III: Group Theory (L 8, T 4, Marks 12)
Groups- definition and examples, groups of symmetry transformation- cyclic group, dihedral group, permutation group; subgroups, Lagrange's theorem, cosets, conjugacy classes; group representation; Continuous or Lie groups, generators of continuous group, special orthogonal groups- SO(2), SO(3); unitary groups- U(1), SU(2).

Unit IV: Tensor Analysis (L 8, T 4, Marks 12)
Basics of tensor algebra, contravariant and covariant tensors, line element and metric tensor, associated tensors, Christoffel's symbols, geodesics, covariant derivatives, Riemannian Christoffel's tensor or curvature tensor, Bianchi identities.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20

End Semester: 60

Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

After the completion of this course

(1) the student will gain the knowledge of different mathematical methods which are required for better understanding of theoretical physics courses such as classical mechanics, quantum mechanics, classical electrodynamics, condensed matter physics, statistical mechanics etc.

(2) the student will be able to deal with partial differential equations that appear in physical problems.

(3) the student will be equipped with Green function technique which will help him to deal with higher level problems in physics.

(4) the student will gain the knowledge of group theory and tensors. This will help him to learn advanced theoretical physics courses such as quantum field theory, particle physics, general relativity, cosmology etc. and also help him to pursue research in relevant areas.

Suggested Readings:

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, Elsevier Academic Press.
2. Mathematical Method for Physics and Engineering, K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press.
3. Essential Mathematical Methods for the Physical Sciences, K. F. Riley and M. P. Hobson, Cambridge University Press.
4. Mathematical Methods in the Physical Sciences, Mary L. Boas, John Wiley & Sons.
5. Mathematical Physics : Basics, S. D. Joglekar, Universities Press.
6. Mathematical Physics : Advance, S. D. Joglekar, Universities Press.
7. Mathematical Physics with Application, Problems and Solution, U. Balakrishnan, Ane Books Pvt. Ltd.
8. Elements of Group Theory for Physicists, A.W. Joshi, New Age International.
9. Group Theory in Physics, J. F. Cornwell, Academic Press.
10. Group Theory in a Nutshell for Physicists, A. Zee, Princeton University Press.
11. Tensor Calculus, Barry Spain, Radha Publishing House (Kolkata).
12. General Theory of Relativity, P. A. M. Dirac, Prentice-Hall of India.
13. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, S. Weinberg, Wiley and Sons.

Course Code: PH-C-II
Course Title: Classical Mechanics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-4

Course Objectives:
1. Acquaint the learners with the subject of classical mechanics in the context of the language and methods of modern nonlinear dynamics.
2. Enable the learners to make a smooth transition from classical mechanics to quantum mechanics and nonlinear dynamics.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I:(L 8, Marks 8)
Review of Newtonian mechanics, Mechanics of a system of particles, Constraints of motion and their classification, Generalised co-ordinates, D' Alembert's principle, Lagrange's equations of motion, Hamilton's principle, Symmetries and conservation theorems, Cyclic coordinates. Flows in phase space, solvable vsintegrable, equilibria and linear stability theory, bifurcations in Hamiltonian systems.

Unit II: (L 15, Marks 15)
Motion in a central potential, Maps, winding numbers and orbital stability, Hidden symmetry in the Kepler problem, Small Oscillations, Solution of one-dimensional harmonic oscillator problem, Forced oscillations in one dimension, Damped harmonic motion in one dimension-general solution of the problem, Displacement as a function of time, Systems with many degrees of freedom, Eigen value equation and normal co-ordinates. Integrable and chaotic oscillations, return maps, area preserving maps, deterministic chaos.

Unit III: (L 12, Marks 12)
Lagrangian dynamics and transformations in configuration space, geometry of motion in configuration space, canonical moment and covariance of Lagrange’s equation in configuration space. Hamiltonian dynamics and transformations in phase space, Generating functions, Poisson brackets, Integrable canonical flows, Hamilton-Jacobi equation, Action-angle variables.

Unit IV: (L 15, Marks 15)
Linear transformations, rotations and rotating frames, similarity transformations, linear transformations and eigen value problem, dynamics in rotating reference frames.
Rigid Body Dynamics, Definition of Rigid body, Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top, Integrable and non-integrable problems.

Unit V: (L 10, Marks 10)
Noncanonical flows, flows on spheres, local vs complete integrability, globally integrable noncanonical flows, attractors, Damped driven Euler-Lagrange dynamics, Liapunov exponents,

geometry and integrability. Damped driven Newtonian systems, period doubling, fractal and multifractal orbits in phase space, strange attractors, the two frequency problem.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

1. Understand the basic concepts of Lagrangian and Hamiltonian dynamics.
2. Understand the basic concepts of modern nonlinear dynamics.
3. Understand canonical and noncanonical flows.
4. Make a smooth transition from classical to quantum mechanics.

Suggested Readings:

1. Classical Mechanics, Joseph L. McCauley, Cambridge University Press.
2. Classical Mechanics, H.Goldstein, Addison Wesley.
3. Classical Mechanics, N.C. Rana& P.S. Joag, Tata McGraw Hill.
4. Classical Mechanics of Particles and Rigid Bodies, Kiran C Gupta, Wiley Eastern Limited.
5. Introduction to Classical Mechanics, R.G. Takwale& P.S. Puranic, Tata McGraw Hill.

Course Code: PH-C-III
Course Title: Quantum Mechanics-I
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

(a) Acquaint the learners Fundamental concepts of Quantum Mechanics.
(b) Acquaint the learners with Dirac notation.
(c) Enable the learners to solve simple quantum mechanical problems.
(d) Introduce the concepts of symmetry and conservation laws
(e) Introduce the techniques of angular momentum algebra

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Fundamental Concepts (L 25, Marks 25)

Overview of wave mechanics, Schrödinger equation, application to some important physical problems: particle in a box, simple harmonic oscillator, delta function potential, spherical well potential, hydrogen atom. Kets, Bras and Operators, Base Kets and Matrix Representations, Measurements, Observables and Uncertainty Relations, Generalized uncertainty principle, Change of basis, Wave functions in Position and Momentum Space.

Unit II: Quantum Dynamics (L 15, Marks 15)
Schrödinger picture, Heisenberg picture, Time evolution and the Schrödinger equation, Heisenberg equation, time evolution of the simple harmonic oscillator**,** Symmetries, Conservation laws and Degeneracy, Spatial and Time translation, Parity, Time reversal, Density operators and Pure versus Mixed Ensembles.

Unit III: Angular Momentum (L 20, Marks 20)
Rotation, Angular Momentum and Unitary groups, commutation relations, , Eigenvalues and Eigenstates of Angular Momentum, Ladder operators and their matrix representations, the Stern Gerlach Experiment , Spin angular momentum and Pauli matrices, Addition of Angular momentum, Clebcsh Gordon Coefficients**,** Identical particles, Many particle systems, Symmetric and anti-symmetric wave functions, Slater's determinant, Pauli's exclusion principle, Wigner-Eckart theorem, Spherical tensors.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
At the completion of this course, a learner is expected to

1. Understand the basic concepts of quantum mechanics.
2. Solve simple quantum mechanical problems.
3. Understand quantum dynamics.
4. Write down eigen values and eigen states of angular momentum.

Suggested readings:

1. Modern Quantum Mechanics, J.J. Sakurai, Addison Wesley
2. Quantum Mechanics, L.I. Schiff, McGraw Hill
3. Quantum Mechanics, Bransden and Joachain, Pearson Education
4. Quantum Mechanics, Powell and Craseman, Narosa Publishing House
5. Quantum Mechanics, R. Shankar, Kluwer Academic
6. Quantum Mechanics, D.J. Griffiths, Pearson Education
7. Quantum Mechanics, Mathews and Venkatesan, McGraw Hill
8. Quantum Mechanics, Richard L. Liboff, Pearson Education

Course Code: PH-C-IV
Course Title: Quantum Mechanics II
Nature of the Course: Core
Total credits assigned: 04
Distribution of Credits: Theory - 4

Course Objectives:
(a) Acquaint the learners with the approximation methods in Quantum Mechanics.
(b) Introduce the quantum mechanical treatment of scattering
(b) Introduce the learners to the relativistic quantum mechanics

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Time Independent Approximation Methods (L 30, Marks 30)
Time independent perturbation theory and its application: Non degenerate case, Degenerate case, Stark effect, Fine structure and Zeeman Effect, Hyperfine splitting, Variational method and its application, Ground state of helium, Hydrogen molecule ion, WKB Approximation and its application.

Unit II: Time dependent approximation methods (L 10, Marks 10)
Time dependent potentials: the Interaction picture, Time dependent perturbation theory, Two level systems, Emission and absorption of radiation, Spontaneous emission, Applications to Interactions with Classical Radiation field, Adiabatic approximation, Sudden approximation.

Unit III: Scattering Theory (L 8, Marks 8)
The Lipmann-Schwinger Equation, the Born Approximation, Optical Theorem, Eikonel Approximation, Free Particle States: Plane versus Spherical waves, Method of partial waves, Low-energy scattering and Bound states, Resonance scattering, Identical Particles and Scattering.

Unit IV: Relativistic Quantum Mechanics (L 12, Marks 12)
Brief overview of Special Theory of Relativity, Four vectors, Klein Gordon Equation, Dirac Equation, Spin angular momentum, Dirac matrices, covariant form of Dirac equation, Ideas of Second Quantization, Quantization of Klein Gordon and Dirac fields.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
At the completion of this course, a learner is expected to

(a) Understand the idea of different approximation techniques in quantum mechanics
(b) Understand the quantum mechanical approach to scattering
(c) Understand the consequences of incorporating special theory of relativity in quantum mechanics.

Suggested readings:

1. Modern Quantum Mechanics, J.J. Sakurai, Addison Wesley.
2. Quantum Mechanics, L.I. Schiff, McGraw Hill.
3. Quantum Mechanics, Bransden and Joachain, Pearson Education.
4. Quantum Mechanics and Path Integrals, R.P. Feynman, Dover Publications.
5. Advanced Quantum Mechanics, J. J. Sakurai, Prentice Hall of India.
6. Quantum Mechanics, R. Shankar, Kluwer Academic/Plenum Publishers.
7. Relativistic Quantum Mechanics, J. D. Bjorken and S. D. Drell, McGraw Hill.

Course Code: PH-C-V
Course Title: Condensed Matter Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

At the completion of this course, a student will be able to

1. Understand the fundamentals of Condensed Matter Physics.

2. Know about different lattice structures, behavior and importance of crystalline state, contribution of X-Ray Diffraction in Crystallography, importance of defects and imperfections in a crystal etc.

3. Understand the behavior in solids that depend primarily on the motion of electrons inside the solid and appreciate the important role of electrons.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Crystallography (L 12, Marks 12)
Bravais lattices (two and three dimensions), typical crystal structures (sc, fcc, bcc, closed-packed structures), reciprocal lattice. Interaction of X-Rays with matter, absorption of X-Rays, Elastic scattering from a perfect lattice, X-Ray diffraction, Bragg's law, Laue, Powder and Rotating Crystal method, Scattering Factor, Structure Factor.

Unit II: Imperfections in Crystalline solids (L 10, Marks 10)
Introductory concepts, Point defect; Schottky, Frenkel defects, Color centers, Dislocations, Diffusion, Fick's law.

Unit III: Conduction electrons in crystalline solids (L 12, Marks 12)
Periodic potential, Bloch theorem, Kronig Penney model, Electronic energy bands, E-k diagram, Brillouin zone, Effective mass, metals, insulators and semiconductors.

Unit IV: Magnetic Properties of Materials (L 14, Marks 14)
Introductory concepts, Langevin diamagnetism, Paramagnetism due to free ions (Quantum Theory) and conduction electrons (Pauli paramagnetism), Molecular field theory of Ferromagnetism, Domains, Hysteresis loop, Antiferromagnetism, Ferrimagnetism.

Unit V: Superconductivity (L 12, Marks 12)
Introductory concepts, Meissner Effect, Ideal conductor and Superconductor, London equation, Thermodynamics of superconducting transition, Isotope effect, introduction to BCS theory, Cooper pair, Basic idea on High temperature superconductivity.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc. : 20

Written Test : 20

End Semester: 60

Written Test : 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

The course will

1. Equip a student with basic concepts of Condensed Matter Physics so that the knowledge can be applied for further development of the subject.

2. Enable a student to work in both theoretical and experimental aspects of Condensed Matter Physics. 3. Help the students in thorough learning of the concepts associated to the course through the numerical, quizzes, assignments, projects etc.

Suggested Readings:

1. Introduction to Solid State Physics, C. Kittel, John Wiley & Sons.

2. Solid State Physics, A. J. Dekker, Macmillan India Ltd.

3. Elementary Solid State Physics, M. A. Omar, Pearson Education.

4. Crystallography Applied to Solid State Physics, A.R. Verma and O.N. Srivastava, New Age

International. 5. Solid State Physics, N. W. Ashcroft and N. D. Mermin, Brooks/cole

Course Code: PH-C-VI
Course Title: General Lab I
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Lab-4

Course Objectives:

1. To develop practical knowledge by applying the experimental methods and to correlate with the Physics theory.
2. To learn the usage of electrical and optical systemsfor various measurements.
3. To apply the analytical techniques and graphical analysis to interpret the experimental data.
4. To learn error propagation and its role in making conclusions.

List of Experiments:

1. To draw the calibration curve of the Jamin's interferometer and then to find the refractive index of air at room temperature and pressure
2. To determine the wavelength of light from a monochromatic source using Michelson's interferometer and then to determine the difference of wavelength for Sodium D lines.
3. To determine the wavelength of light from a monochromatic source using Fabry-Perot interferometer and then to determine the difference of wavelength for Sodium D lines.
4. To determine the wavelength of He-Ne laser light.
5. To study the normal and anomalous Zeeman effects.
6. To determine the value of e/m by bar magnet method.
7. To determine the value e/m by magnetron method.
8. To determine the energy band gap of a semiconductor using p-n junction diode.
9. To draw the frequency response curve of a CE transistor amplifier and also to find the input impedance of the amplifier.
10. To determine the velocity of sound using CRO.

11. To study the plateau and optimal operating voltage of a Geiger-Müller counter.
12. To measure the half-life of meta-stable Barium-137.

(Internal BOS of the department is authorized to modify the list of experiments whenever necessary.)

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Viva Voce:	20
End Semester: 60	
Laboratory experiments:	60

(One experiment from the list of experiments to be performed)

Expected Learning Outcome:
On successful completion of this course, students should be able to:
1.Learn to minimize contributing variables and recognize the limitations of equipment.
2.Describe the methodology of science and the relationship between observation and theory.
3.Participate in the methodology by performing laboratory exercises.

Suggested Readings:
1. B.L. Worsnop and H. T. Flint, Advanced Practical Physics, Asia Publishing House.
2. Optics, A.K. Ghatak, Tata McGraw Hill
3. Fundamentals of Optics Jenkins and White McGraw Hill
4. Optics A. R Ganesan, Eugune Hecht

Course Code: PH-C-VII
Course Title: Electrodynamics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-03, Tutorial-1

Course Objectives:
1. This course utilizes physical and mathematical principles to provide in-depth analysis of the behaviour of electricity and magnetism in matter.
2. To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them in various situations.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: (L 9, T 4, Marks 13)
Introductory ideas, Propagation of electromagnetic waves in different media, Dispersion, Frequency dependence of σ, μ and ε, dispersion in non-conductors, anomalous dispersion, free electrons in conductors and plasma, Wave Guides, TE waves in rectangular wave guide. Coaxial transmission lines

Unit II: (L 12, T 10, Marks 22)
Electromagnetic radiation: Retarded potentials, electric dipole radiation, radiation from an arbitrary distribution of charges and current, Lienard-Wiechert potentials, fields due to uniformly moving charge, and accelerated charge, Linear and circular acceleration, angular distribution of radiated power, Bremhstrahlung and Synchrotron radiation, Radiation reaction, Abraham-Lorentz formula.

Unit III: (L 15, T 10, Marks 25)
Structure of space-time, Four vectors and Lorentz transformation, Proper time and velocity, Relativistic energy and momentum.
Magnetism as relativistic phenomena, Potential formulation of relativistic electrodynamics Electromagnetic field tensor, Dual tensor, Covariant formulation of electrodynamics.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
Students will have achieved the ability to:
1. Describethe nature of electromagnetic wave and its propagation through different media and interfaces.
2. Explain charged particle dynamics and radiation from localized time varying electromagnetic sources.
3. Understand potential formulation and magnetism in relativistic case.

Suggested Readings:

1. 'Introduction to Classical Electrodynamics', D.J. Griffiths, Prentice Hall of India.
2. 'Classical Electrodynamics', J.D. Jackson, John Wiley.
3. 'Electromagnetic waves and Radiating systems', Edward C Jordan and Keith G. Balmain, PHI Pvt. Ltd.
4. 'Electromagnetic Wave and radiating systems', Jordan, E.C. and Balmain, K.G., Prentice Hall of India

Course Code: PH-C-VIII
Course Title: Atomic and Molecular Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-04

Course Objectives:

The objective of this course is to make a student

1. Learn the physics of the atoms and molecules
2. Become familiar with various branches of spectroscopy and their applications
3. Equip with basic spectroscopic techniques and instrumentation
4. Learn to use spectroscopic techniques to identify materials
5. Learn theoretical background of laser and its application in various disciplines

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Atomic Physics (L 23, Marks 23)

Fine structure of hydrogen atom, relativistic correction, Lamb shift, Spectra of alkali atoms, spin-orbit interaction and fine structure in alkali atoms, level scheme of two electron atoms-equivalent and nonequivalent electrons, ground and excited states of two electron atoms, interaction energy in L-S and j-j coupling for two electrons, Zeeman effect, Paschen-Back effect, Stark effect, hyperfine structure of hydrogen and alkali atoms, spectra of multi electron atoms, X-ray spectra, width and shape of spectral lines

Unit II: Molecular Physics (L 25, Marks 25)

Regions of the spectrum, types of molecules, Rotational Spectra for rigid and non rigid rotators, isotopic effect in rotational spectra, intensity of spectral lines, information derived from rotational spectra, microwave spectrometer, Vibrational spectra for anharmonic oscillator, vibration-rotation spectra, Infra-red spectrometer, Electronic spectra of molecules-Born-Oppenheimer approximation, vibrational analysis of electronic band spectra, fine structure of electronic band spectra, Fortrat Diagram, Raman spectra, Raman spectrometer, Photoelectron spectroscopy, Spin resonance spectroscopy- NMR, ESR, Mössbauer spectroscopy, Fourier Transform Spectroscopy

Unit III: Lasers (L 12, Marks 12)

Fundamentals of Lasers-properties, basic elements, threshold condition, rate equations: two, three and four levels. Population inversion, Laser resonator and modes, Ammonia Masers, types of laser: solid state laser, gas laser, semi conductor laser, applications of laser spectroscopy, Laser Cooling.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20

End Semester: 60

Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

After completing this course a student can

1. Determine the atomic and molecular structures
2. Analyze and demonstrate a spectra to identify and quantify information about atoms and molecules
3. Demonstrate the interaction of electromagnetic spectra with matter and the associated type of spectroscopy
4. Identify elements present in a sample and in the universe using spectroscopic techniques
5. Apply knowledge of spectroscopy or laser spectroscopy in various disciplines of Physics, Chemistry, Atmospheric Science, Astronomy, Laser Communication, remote sensing etc

Suggested Readings:

1. Physics of Atoms and Molecues, B. H. Bransden and C. J. Joachain, 2rd Edition, Dorling Kindersley (India) Pvt. Ltd,. Pearson Education in South Asia.
2. Atomic Spectra, H.E. White McGraw Hill.
3. Atomic Physics, Max Born, Dover Publications, Inc., New York.
4. Molecular spectroscopy,Banwell and McCash Tata McGraw Hill
5. Molecular Structure and Spectroscopy G. Aruldhas Prentice Hall of India
6. Molecular Spectra and Molecular Structure G. Herzberg, McGraw Hill
7. Lasers and Nonlinear Optics, B.B. Laud New Age International
8. Laser Spectroscopy-Basic Concepts and Instrumentation, Wolfgang Demtröder, Springer
9. Modern Spectroscopy, J M Hollas, John wiley& Sons
10. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut

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Course Code: PH-C-IX
Course Title: General Lab II
Nature of the Course: Core
Total Credit assigned: 4
Distribution of Credits: Lab - 04

Course Objectives:

At the completion of this course, a student will be able to

1. Understand the basic techniques of design and analysis of simple transistor and OPAMP circuit.
2. Apply the knowledge to design and study different electronic circuits.

List of Experiments:

1. To design astable and monostable multivibrator using 555 IC.
2. To design and study D/A converter using R-2R Ladder network.
3. To design and study OPAMP as a differentiator and integrator.
4. To draw the frequency response curve of an RC coupled amplifier with and without negative feedback and compare the bandwidth.
5. To design a transistor amplifier for a specific gain using Voltage divider biasing method.
6. To design a RC Oscillator and Wien Bridge Oscillator for generating Sinusoidal oscillation of frequency 200 Hz and 3 KHz.
7. To design and construct basic flip-flops R-S, J-K, J-K Master slave flip-flops using gates and verify their truth tables.
8. To realize One & Two Bit Comparator and study of 7485 magnitude comparator.
9. To realize and study Shift Register.
   a) SISO (Serial in Serial out)
   b) SIPO (Serial in Parallel out)
   c) PIPO (Parallel in Parallel out)
   d) PISO (Parallel in Serial out)
10. To design and test 3-bit binary asynchronous counter using flip-flop IC 7476 for the given sequence.
11. To study the characteristic curves of JFET and MOSFET.
12. To design 1st and 2nd order low pass active filters for specific roll off and cut off.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ Attendance/ Class room interaction/Quiz etc.: 20
Viva Voce: 20
End Semester: 60
Laboratory experiments: 60
(One experiment from the list of experiments to be performed)

Expected Learning Outcomes:
This course will enable the students to
1. Design electronic circuits using various electronic components.
2. Analyze the circuits and understand their behaviours.

Suggested Readings:

1. Electronic Principles by Albert Malvino, McGraw Hill Education
2. Digital Principals and applications by Leach and Malvino, McGraw Hill Education
3. Microelectronics by Jacob Millman and Arvin Grabel, McGraw Hill Education

Course Code: PH-C-X
Course Title: Nuclear Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:
After successful completion of the course, the student will

(a) Have a basic knowledge of the nuclear force and its properties
(b) Be able to visualize the nature of interaction of nucleons inside deuteron nucleus as well as in general nucleon-nucleon scattering
(c) Be acquire knowledge about different theoretical models regarding nucleus as well as to apply those in determining nuclear properties
(d) Grasp knowledge about nuclear reactions and their various mechanisms along with an wide understanding of the decay process
(e) Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail
(f) Know about the basic working principles of various nuclear detectors

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: (L 8, Marks 8)

Review of nuclear properties, Nuclear Forces: properties of nuclear forces, isotopic spin formalism, generalized Pauli's exclusion principle, meson theory of nuclear forces.

Unit II: (L 15, Marks 15)

Two body problem: General form of nucleon-nucleon forces, the deuteron problem (ground states and excited states), central and tensor forces, nucleon-nucleon scattering at low energies.

Nuclear models: Review of liquid drop model and its applications, shell model, L-S coupling, magnetic moment and Schmidt lines.

Unit III: (L 15, Marks 15)

Nuclear reactions: Reaction channels, nuclear reaction mechanisms, scattering cross-section, compound nucleus, partial wave analysis of nuclear reaction, resonance, Breit-Wigner single level formula, B-W formula incorporating spin, neutrino hypothesis and general features of β-ray spectrum, Fermi's theory of β-decay, Curie plot, selection rules.

Unit IV: (L 10, Marks 12)

Elementary Particle Physics: Fundamental forces, Elementary particles and their classification, characteristics of the elementary particles, quantum numbers, behaviour under charge conjugation, time reversal and parity operation, Isotopic multiplet and Gellmann-Nishijima scheme, SU (3) classification and Quark model, Standard model.

Unit V: (L 12, Marks 10)

Detection of radiations: gas filled counters, scintillation detectors, semiconductor detectors.

Mode of Assessment/ Assessment Tools

Internal: 40

Assignment /Presentation/ attendance/ Classroom interaction/quiz etc.: 20

Written Test: 20

Final (End Semester): 60 (Written Test)

Expected learner outcome:

This course will enable the students to

1. Develop knowledge regarding nucleus, its properties, nuclear force, nuclear reactions and mechanisms, nuclear detectors as well as elementary particles and the properties related to them
2. Successfully apply the same knowledge in solving problems in the field of nuclear and particle Physics.

Suggested readings:

1. Nuclear Structure Vol. 1(1969), A. Bohr and B.R Motteison

2. Nuclear Structure Vol. 2(1975), Benjamin and Reading A

3. Introductory Nuclear Physics, Kenneth S. Krane, Wiley, New York,1988

4. Atomic and Nuclear Physics Vol. 2, S.N. Ghosal, S. Chand and Co

5. Introduction to High Energy Physics, P.H. Perkins, Addison Wesley London,1982

6. Nuclear Physics Vol. 1 & 2, Shirokov Yudin, Mir Publishers Moscow 1982

7. Introduction Elementary Particles, D.J. Griffiths, Harper and Row New York,1987

8. Introduction to Nuclear Physics, H.A. Enge Addison-Wesley,1975

9. Nucleon-Nucleon Interaction, G.E. Brown and A.D. Jackson North- Holland, Amsterdam, 1976

10. Theory of Nuclear Structure, M.K. Pal, Affliliated East-West Madras,1982

11. Introductory Nuclear Physics, Y.R. Wagmare, Oxford University Press, Bombay,1981

12. Elementary Particles, J.N. Longo, McGraw Hill, New York,1971

13. Atomic Nucleus, R.D. Evans, McGraw Hill, New York, 1955

14. Nuclear Physics 2nd ed., I. Kaplan, Narosa, Madras,1989

15. Concepts of Nuclear Physics, B.L. Cohen, Tata McGraw Hill, Bombay,1971

16. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International

17. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley & Sons, Inc.

Course Code: PH-C-XI
Course Title: Statistical Mechanics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-03, Tutorial-1

Course Objectives:
The Statistical Mechanics is one of the most important branches of physics which is required to understand the properties matter in bulk on the basis of the dynamical behaviors of its microscopic constituents. As such the objectives of this course are:

(1) To introduce the advance concepts of Statistical Mechanics so that students will be equipped with a sufficient knowledge of the subject.
(2) To develop the critically thinking ability of students to understand the diverse physical phenomena.
(3) To develop the interest and ability among students to solve challenging physical problems by the application of techniques of Statistical Mechanics in future.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Introduction and formulation of quantum Statistics (L 9, T 3, Marks 10)
Historical introduction of statistical mechanics, ergodic hypothesis, ensembles, partition function, grand partition function, postulates of quantum statistical mechanics, density matrix, pure and mixed states, density matrix and partition function of a system of free particles, classical limit of the partition function, BE and FD statistics.

Unit II: Ideal Bose and Fermi systems (L 10, T 3, Marks 15)
Ideal Bose gases, Bose-Einstein condensation, thermodynamic behaviour of an ideal Fermi gas, Pauli paramagnetism, Landau diamagnetism.

Unit III: Statistical Mechanics of Interacting systems (L 11, T 4, Marks 18)
Clusters, classical cluster expansion, formalism of second quantization, creation and annihilation operators and their properties for bosons and fermions, Hamiltonian in terms of second quantized operators, imperfect Bose and Fermi gases.

Unit IV: Phase transitions (L 8, T 2, Marks 10)
Dynamical model of phase transition, the Ising model (one dimension), liquid helium, He-4and He-3, the lambda-transition, Tisza's two-fluid model, the theories of Landau and Feynman, equilibrium properties near absolute zero, superfluidity.

Unit V: Fluctuations (L 7, T 3, Marks 7)
Mean square deviation, fluctuation in ensembles, thermodynamic fluctuations, spatial correlation in a fluid, Einstein-Smoluchowski theory of Brownian motion, approach to equilibrium: the Fokker-Planck equation.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
After the completion of this course it is expected that:
(1) The students will be equipped with a sufficient knowledge of the Statistical Mechanics and hence will be able to look critically for analyzing any physical phenomena.
(2) May motivate students to solve any challenging physical problem in future.

(3) Will draw interest to the subject to pursue further higher study in future and will ultimately help to contribute new knowledge.

Suggested Readings:

1. Statistical Mechanics, R. K. Patharia, Butterwork Heinemann.
2. Statistical Mechanics, K. Huang, John Wiley and Sons.
3. Statistical Mechanics, K. M. Khanna, Today and Tomorrow, New Delhi.
4. Statistical Mechanics, B. K. Agarwal, M. Eisner, New Age International Publishers.
5. Fundamentals of Statistical Mechanics, B.B. Laud, New Age International Publishers.
6. A Primer of Statistical Mechanics, R. B. Singh, New Age International Publishers

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Course Code: PH-C-XII
Course Title: Plasma Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-04

Course Objectives:

1. Understand collective nature of plasma dynamics.
2. Describe the motion of charged particles in varying electric and magnetic fields.
3. Derive fluid description of collective plasma motion.
4. Learn foundations of plasma waves and instabilities.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: (L 10, Marks 10)

Definition of plasma, concept of temperature, Debye shielding, plasma parameters, criterion for plasma, Classification of Plasma, Applications of Plasma Physics.

Unit II: (L 20, Marks 20)

Motion of charged particles in electromagnetic fields uniform E and B fields, non-uniform fields, diffusion across magnetic fields, varying E and B fields, Adiabatic invariants, Magnetic mirror

Unit III: (L 15, Marks 15)

Plasma as fluids: Introduction, relation of plasma physics to ordinary electromagnetics, Fluid equation of motion, Fluid drifts perpendicular and parallel to B, Plasma approximation.

Unit IV: (L 15, Marks 15)

Wave phenomena in plasma: phase and group velocities, plasma oscillation, electron plasma waves, ion-acoustic waves, propagation parallel and perpendicular to the magnetic field, propagation through ionosphere and magnetosphere. Space and Astrophysical Plasma, Van Allen Belts

Mode of Assessment/ Assessment Tools (%)
In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

On completion of the course, the student shall be able to:
1. Define plasma and its fundamental parameters, distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena
2. Determine the velocities (drift velocities) of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time
3. Classify the electrostatic and electromagnetic waves that can propagate in magnetised and non-magnetised plasmas, and describe the physical mechanisms generating these waves
4. Define and determine the basic transport phenomena such as plasma resistivity, diffusion (classical and anomalous) and mobility as a function of collision frequency and of the fundamental parameters for both magnetised and non-magnetised plasmas

Recommended Readings:

1. 'Introduction to plasma physics',F.F. Chen, Springer.
2. 'Fundamentals of plasma physics',R.A. Bittencourt, Springer-Verlag NY Inc.
3. 'Principles of plasma diagnostics',I.H. Hutchinson, Cambridge University Press.

DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

Course Code: PH-DSE-IA
Course Title: Electronics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04
Course Objectives:
1. To disseminate working knowledge of electronic principle using semiconductor devices
2. To allow students to learn the fundamentals of both analog and digital electronic devices
3. To allow students to apply their knowledge for designing small electronic systems.
4. To introduce students to advanced digital systems like microprocessor and microcontroller

5. To imbibe the spirit of application-oriented learning

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit-I Transistor Fundamentals and Special purpose Electronic Devices: (L 20, Marks20)

BJT amplifier, Emitter follower, impedance matching application, ac models: T and π, analysis, IC circuit current mirror, open collector, pull up resistor. Bootstrapped and Darlington amplifier

Field effect transistors: JFET, MESFET and MOSFET, structure, working, derivation of the equations of IV characteristics under different conditions, JFET as amplifiers and switch-MOSFET, E- MOSFET, Digital switching, active load, introduction to CMOS and FINFET technology.

Silicon Controlled Rectifier, Liquid Crystal Display, OLED, Solid State battery

Unit II: Integrated Circuits: Operational Amplifier (L 15, Marks15)

Differential amplifier: circuit configuration, dual input, balanced output differential amplifier, DC-AC analysis, inverting and non-inverting inputs,

Review of applications of Operational amplifiers

Applications of linear digital ICs Comparator, A/D, D/A, PLL, VCO, interfacing Circuit

Instrumentation amplifier, Schmitt Trigger Circuits Active filters (Filter approximation,) Filtering and noise reduction.

Unit III: Introduction to Memory element, Microprocessor and Microcontroller (L 15, Marks 15)

RAM and ROM as memory element.

Introduction to microprocessor: Architecture of digital computer system, Von Neumann and Harvard architecture, different microprocessors, architecture, pin diagram, different bus, programming model using intel 8085, register set, memory organization, instruction set, simple programming: addition, subtraction, multiplication etc.

Introduction to 8051 microcontroller and embedded systems, instruction set, addressing mode, programming, time delay generation, look up table implementation etc.

Unit IV: Digital transmission (L10, Marks 10)

Sampling theorem, quantization, Dynamic range, Companding, Pulse code modulation (PCM), Delta modulation, granular noise, slope overloading, adaptive delta modulation, differential PCM,

Mode of Assessment/ Assessment Tools (%)
In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)
Expected Learning Outcome:
The student will be able to
1. Critically analyze analog and digital electronic circuits
2. Design small electronic systems as per design specifications
3. Write assembly language programs for doing simple arithmetic operation in microprocessor and microcontroller.
4. Apply their knowledge for real life problems solving in electronic

Suggested Readings:

1. Electronic Principles A.P. Malvino Tata McGraw Hill
2. Op amps and Linear Integrated Circuits R.K. Gaekwad Prentice Hall of India
3. Modern Digital Electronics, R P Jain, 4^{th} Edition, 2010, TataMcgraw Hill
4. Integrated Electronics: Analog and Digital Circuit Systems J. Millman and C. Halkias McGraw Hill
5. Digital Principles and Applications D.P. Leach and A.P. Malvino Tata McGraw Hill
6. Semiconductor Materials and Devices M.S. Tyagi John Wiley and Sons
7. Physics of Semiconductor Devices S.M. Sze Wiley Eastern Ltd.
8. The Art of Electronics P. Horowitz and W. Hill Cambridge University Press
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
10. The 8051 Microcontroller and Embedded system,Mazidi, Mazidi and McKinlay, Pearson Education

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Course Code: PH-DSE-IB
Course Title: Advanced Mathematical Physics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of Credit: Lecture - 3, Tutorial - 1

Course Objectives:
At the completion of this course, a student will be able to
(1) Write a complex problem in higher level Physics in the language in Mathematics.
(2) Identify a range of diverse mathematical techniques to formulate and solve a complex problem in higher level Physics.

(3) Analyze various mathematical concepts and methods required in higher level Physics.
(4) Apply the knowledge and understanding of these mathematical techniques to gain insight into a number of advance branches of physics like Theoretical Physics, Particle and High Energy Physics, Physics of Gravity, Cosmology etc.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Nonlinear Dynamics (L 16, T 5, Marks 20)
Overview: Significance of nonlinearity; one-dimensional flows: flows on the line and the circle, fixed points and stability, existence and uniqueness, impossibility of oscillation, potentials; bifurcations: saddle-node bifurcation, transcritical bifurcation, pitchfork bifurcation, imperfect bifurcations and catastrophes, ghosts and bottlenecks, applications to physical problems; two-dimensional flows: linear systems, classification of linear system; phase plane: phase portraits, fixed points and linearization; chaos: strange attractors, chaos on a strange attractor, Lorentz map, Logistic map, Henon map, Liapunov exponent; Fractals: countable and uncountable sets, self-similarity, dimension of self-similar fractals, applications to physical problems.

Unit II: Topology (L 13, T 5, Marks 18)
Overview: topology and geometry in physics, maps, linear maps, images and kernels, dual vector space; topological spaces: definition and types, compactness, connectedness; homeomorphisms and topological invariants; Nielsen-Olensen vortex, topological excitations; homology and homotopy groups; fibre, vector and principal bundles; anomaly, abelian and non-abelian anomaly; some examples and applications.

Unit III: Differential Geometry (L 16, T 5, Marks 22)
Manifolds: Definition, calculus of manifolds; Killing vectors: definition, Killing vector fields, conformal Killing vector fields; non-coordinate bases, differential forms, duality transformation; submanifolds; complex manifolds: definition, calculus on complex manifolds, complexifications, complex differential forms; Hermitian manifolds: definition, Hermitian differential geometry, Kahler form, torsion and curvature; Kahler manifolds: definition, Kahler geometry, Kahler differential geometry; moduli space; matter fields and covariant derivatives; some examples and applications.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome: After the completion of this course it is expected that this course will

(1) Equip students with required mathematical skills to succeed in Physics.
(2) Develop the analyzing ability of the students to solve critical problems in Physics.
(3) Enable the students to pursue a research career in Physics and will ultimately help to contribute new knowledge.

Suggested Readings:

1. Nonlinear Dynamics and Chaos, S. H. Strogatz,Perseus Books Publishing.
2. Stability, Instability and Chaos: An Introduction to the Theory of Nonlinear Differential Equations, P.Glendinning, Cambridge University Press.
3. Introduction to Applied Nonlinear Dynamical Syatem and Choas, Stephen Wiggins, Springer.
4. Geometry, Topology and Physics, M. Nakahara, IOP Publishing.
5. Calculus on Manifolds, M. Spivak, Addition-Wesley Publishing.
6. Topology, Geometry and Gauge Fields, G. L. Naber, Springer.
7. Topology and Geometry in Physics, E. Bick and F. D. Steffen (Eds.), Springer.

Course Code: PH-DSE-IIA
Course Title: Theory of Relativity
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:
1. Acquaint the learners with the special theory of relativity, space time continuum.
2. Introduce the basic concepts of tensor calculus
3. Introduce the learners to the general theory of relativity

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Special Theory of Relativity (L 20, Marks 20)
Galilean transformation, Michelson-Morley experiment, Einstein's postulates, Lorentz Transformations and basic kinematical results of special relativity, addition of velocities, relativistic momentum and energy of a particle, four vectors, mathematical properties of the space-time of Special Relativity, matrix representation of Lorentz transformation, transformation of electromagnetic fields.

Unit II: Tensor Calculus (L 20, Marks 20)
Tensors, Tensors as geometrical objects, covariant, contravariant and mixed tensors, contraction, covariant differentiation, the metric tensor, Christoffel symbols, Riemann curvature tensor, metric tensor and gravity, geodesics, parallel transport, Lie Transport and Killing vectors.

Unit III: General Theory of Relativity (L 20, Marks 20)

Curvature of space time, properties of the curvature tensor, Bianchi identity, Ricci Tensor, physics in curved space time, Einstein field equation, general properties of gravitational field equations, spherically symmetric geometry, Schwarzschild metric, Freidman space-time, de Sitter space-time, Gravitational waves, generation of gravitational waves and properties.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcomes:

1. Understand the ideas of space time continuum, four vectors
2. Understand tensors as geometrical objects, understand coordinate free formulation of physical laws
3. Understand the basic ideas of geometrical formulation of gravity
4. Understand basic ideas of cosmology

Suggested Readings:

1. Special Theory of Relativity, R. Resnick, McGraw Hill
2. Tensor Calculus, D.C. Kay, Schaum's Outlines
3. Tensor Calculus, P. A. M. Dirac, Prentice-Hall of India
4. Gravitation and Cosmology, S. Weinberg, McGraw Hill
5. Gravitation, T. Padmanabhan, Cambridge University Press
6. Gravitation, J. A. Wheeler, C. W. Misner and K. S.Thorne, Princeton University
7. Cosmology, J. V. Narlikar, Cambridge University Press

Course Code: PH-DSE-IIB
Course Title: Numerical Methods and Programming
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 03, Lab-01

Course Objectives:

After successful completion of the course, the student will

(a) Get hands on training in problem solving using FORTRAN 77 programming language in LINUX operating system
(b) Learn various numerical methods to solve physical problems as well as programming of such

methods

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: **(L 12 + practical 7, 15 marks)**

Determination of root of functions, solution of nonlinear equations: Bisection method, method of False Position, Newton-Raphson method

Curve fitting: Interpolation, Lagrange Interpolation, Newton Interpolation, Interpolation with Equidistant Points

Unit II: (L 15 + practical 8, 20 marks)

Numerical Differentiation: Finite difference methods, Richardson Extrapolation, Interpolation based methods

Numerical Integration by trapezoidal and Simpson's rule

Solution of Linear Algebraic Equations: Iterative Methods, Inverse of a Square Matrix

Solution of first order ordinary differential equation: Runge-Kutta method

Unit III: (L 10, 10 marks)

Elementary probability theory, Binomial, Poisson and Normal distributions

Unit IV: **(L 18 + practical 5, 15 marks)**

LINUX commands, FORTRAN 77 programming, integer and floating point arithmetic, expressions, built-in functions, executable and non-executable statements, assignment, control and input, output elements, subroutines and functions, operation with files, Programming examples of numerical methods.

Mode of Assessment/ Assessment Tools

Internal: 40

Assignment /Presentation/Test on LINUX user commands/attendance/ Classroom interaction/quiz etc.: 20

Written Test (Theory): 10

Programming Test (Practical): 10

Final (End Semester): 60 (Written Test)

Expected learner outcome:

This course will enable the students to

(a) Apply their knowledge on computer programming and numerical analysis in solving real physical problems
(b) Deal with scientific computing in different research areas of Physics

Suggested readings:

1. Numerical Recipes in C/Fortran Press et al. :Cambridge University Press
2. Fortran 77 :V. Rajaraman : Prentice Hall of India
3. Fortran 77 and numerical methods, C. Xavier
4. How to Solve it by Computer : H. Drowmey Prentice Hall of India

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Course Code: PH-DSE-IIIA
Course Title: High Energy Physics I
Nature of the Course: DSE
Total credits assigned: 04
Distribution of Credit: Theory - 4

Course Objectives:
At the completion of this course, a student will be able to
1. Classify the elementary particles and their interactions.
2. Analyze the formulation of group theory.
3. Apply group theory to quark model and different interactions.
4. Express physical quantities in natural units.
5. Explain the physics of relativistic wave equations.

Unit wise distribution of course contents with unit wise distribution of weight age and contact hours:

Unit I: Introduction to Elementary Particles (L 20, Marks 20)
Historical introduction and classification of elementary particles, intrinsic properties of elementary particles, behaviour of elementary particles under: charge conjugation (C), parity (P), time reversal (T) and G-parity; Gell-Mann-Nakano-Nishijima law, eightfold way (Gell-Mann and Ne'eman classification).

Unit II: Group Theory and The Quark Model (L 25, Marks 25)
Symmetries in physics, Lie groups, unitary and special unitary groups (U(1), SU(2) and SU(3)), Tensor method in SU(n), Young tableaux, Isospin symmetry the quark model, quark-mass formulas, Zweig rule, quark color, hadron wave functions, quark model predictions: magnetic moment, hadron masses.

Unit III: Relativistic Wave Equations (L 15, Marks 15)
Natural units, Lorentz covariance and four vector notation; Klein-Gordon equation; Dirac equation and its covariant form, Dirac gamma matrices, adjoint equation and conserved current,

solution of the Dirac equation (free particle spinors), negative energy states, antiparticles, normalization of spinor and the completeness relations, Lorentz covariance of Dirac equation, bilinear covariants, Dirac equation for zero mass particles (the two-component neutrino), helicity states.

Mode of Assessment/ Assessment Tools (%)

In Semester:	**40**
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester:	**60**
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
After the completion of this course, it is expected that this course will
1. Enable a student to acquire the basic knowledge of elementary particles and their interactions.
2. Enable a student to apply the framework of group theory to particle physics.
3. Prepare a student for advanced topics in field theory and particle physics.
4. Motivate a student to pursue a career in high energy physics.

Suggested Readings:

1. Introduction to Elementary Particles, D. J. Griffiths (John Wiley & Sons).
2. Quarks and Leptons, Francise Halzen and Alan D. Martin (John Wiley & Sons).
3. Introduction to High Energy Physics - Donald H. Perkings (Cambridge University Press).
4. Gauge Theory of Elementary Particle Physics, T. P. Cheng and L. F. Li (Oxford Univ. Press).
5. Physics of Elementary Particles, H. Muirhead (Pergamon Press).

Course Code: PH-DSE-IIIB
Course Title: Condensed Matter Physics I –Electronic Properties of Solids
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

At the completion of this course, a student will be able to

1. Understand the chronology in the Development of the Electron theory in Metals.
2. Understand the importance of Polarisation and Di-electric behavior of material and their primary applications
3. Understand and appreciate the exchange interaction responsible for co-operative magnetic behavior

4. Understand the electron phonon interaction in superconductivity and behavior related to the cooper pair.
5. Understand the Optical properties of materials in terms of electronic band transitions and optical constants.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Electron theory (L 16, Marks 16)
Free electron theory, Energy levels and density of states, Fermi energy, Boltzmann equation, relaxation time, electrical and thermal conductivity of metals, Wiedemann Franz law, T ight binding method.

Unit II: Dielectric and Ferroelectric Properties (L 16, Marks 16)
Polarization, Langevin's theory, Clausius-Mossotti relation, static dielectric constant of solids, complex dielectric constant & dielectric loss, dielectric relaxation, Debye equation. Ferroelectric effect, dipole theory of ferroelectricity, Piezoelectric effect, Pyroelectric effect, Electrostrictive effect, anti-ferroelectricity.

Unit III: Magnetic Properties of a System (L 14, Marks 14)
Magnetic Hamiltonian, Exchange interaction and exchange integral for two-electron system, Heisenberg Hamiltonian, relationship between exchange energy and molecular field, Hartree and Hartree-Fock approximation, Ferromagnetic spin waves

Unit IV: Superconductivity (L 14, Marks 14)
Isotope effect, electron-phonon interaction, Cooper Pair, BCS theory, flux quantization in a superconducting ring, superconducting tunneling, Josephson Effect, SQUIDS

Mode of Assessment/ Assessment Tools (%)
In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc. : 20
Written Test : 20
End Semester: 60
Written Test : 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

The course will

1. Equip a student with quantum mechanical tools for the solution of Condensed Matter Physics problems.
2. Enable a student to work in both theoretical and experimental aspects of Electronic Behavior of Solids.
3. Enable the students for further study and contribution towards the development of the subject.

Suggested Readings:

1. The Theory of transport phenomena in solids, J. M. Ziman, Oxford University Press
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Brooks/Cole
3. Intermediate Quantum Theory of Crystalline Solids, A.O.E. Animallu, Prentice Hall
4. Quantum Theory of Solids, C. Kittel, John Wiley International
5. Elements of Solid State Physics, J.P. Srivastava, Prentice Hall India
6. Introduction to Solid State Theory, O. Madelung, Springer-Verlag
7. Quantum Theory of Solid State, J Callaway, Academic Press 8. Theoretical Solid State Physics, A. Huang, Elsevier

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Course Code: PH-DSE-IIIC
Course Title: Digital and Optical Electronics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

At the completion of this course, a student will be able to

1. To introduce students to digital signal and signal processing principles
2. To introduce students to optical electronic systems
3. To provide students with fundamental principles of optical devices
4. To introduce students to optical communication systems and networks

Unit I: Introduction to digital signal processing (L-15, Marks: 15)

Introduction to digital signals-discrete time signals, classification: power and energy signals, deterministic and random signals etc. Digital processing systems, Introduction to Discrete Time Linear Invariant signals, Impulse response and convolution, Digital Fourier transform and Z-transform, pole zero analysis for stability, implication of poles and zeroes location, Finite duration and infinite duration impulses, FIR and IIR filters.

Unit II: Optical Fiber (L-20, Marks: 20)

The optical regime in electro-magnetic spectrum: characteristics, advantages/disadvantages

Advantage over electronic system: faster, higher band width, economic, security etc. Ray picture and wave picture. Maxwells' equations and propagation of electro-magnetic waves in dielectric medium, reflection and refraction at interfaces, phase and group velocity, concept of coherence, spatial and temporal coherence.

Total internal reflection, evanescent waves and scattering of light in attenuating medium. Light propagation in plan and circular wave guides, Numerical Aperture, Optical fiber classification, material and construction, modes of propagation, Step index and communication grade fibers, losses in fibers, different loss processes, properties, attenuation, dispersion- modal, chromatic and waveguide dispersion, dispersion compensation, DCF, idea of solitons, new fiber designs and Plastic fibers.

Unit III: Optical sources, amplifiers and detectors (L-15, Marks:15)

Energy bands in solids, the E-k diagram, Semiconductor optoelectronic materials, Source: LED, LASER, Diode as lasing medium, LASER basics, semiconductor LASER diode, device structure (hetero junction), materials and characteristics, longitudinal modes of the cavity, DFB and DBR. Photo detectors, semiconductor detectors, Photo diode, P-I-N photodiode, Avalanche photo diode (APD) and photo transistor, Single, Noise in photo-detection; detector performance characteristics. **Optical Amplifiers & Modulators:** Semiconductor optical amplifiers (SOA), EDFA and RAMAN amplifier, characteristics and applications, idea of electro-optic and acoustic modulators

Unit IV: Optical communication system (L-10, Marks: 10)

Basic architecture of an optical communication link, power budget, multiplexing techniques, Wavelength Division Multiplexing (WDM), components of the system: Optical couplers, Tunable sources and filters, optical MUX/DEMUX, Fiber grating, optical add drop multiplexer (OADM), optical circulators, optical cross connects.

Mode of Assessment/ Assessment Tools

In-semester:

Written =20%

Verbal (seminar/viva) = 10%

Assignment = 10%

End-semester

Written = (60%)

Expected Learner Outcome:

The student will be able to

1. Understand the application of optical concepts for device design

2. Analyze optical signals and electronic devices

4. Critically analyze optical communication and network systems

5. Apply the knowledge of optical electronics to design innovative optical device for new age communication systems.

6. Understand and apply digital signal processing concepts

Suggested readings:

1. Digital Signal Processing, J.G. Proakis and D.G.Manolakis, Printice-Hall International Inc.

2. Optical Electronics, Ghatak and Thyagarajan.

3. Fiber Optics, Ghatak and Thyagarajan.

4. Optical communications : Components and Systems, J.H.Franz and V.K.Jain Narosa Publications.

Course Code: PH-DSE-IIID
Course Title: Atmospheric Physics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

The objective of this course is to

1. Introduce the physics and chemistry of the Earth's neutral atmosphere
2. Give an in depth introduction to the physical processes in the atmosphere like dynamics, thermodynamics, radiation etc.
3. Introduce atmospheric composition and their impact on the global climate
4. Introduce the concept of present day climate change
5. Introduce the atmospheres of other other solar system planets

Unit I: Introduction to Earth's Atmosphere (L 15, Marks 15)

Evolution of the Earth's atmosphere, vertical thermal and density structure of the atmosphere, tropopause dynamics, Environmental lapse rate, hydrostatic equation, conservation laws-momentum, mass, energy, Navier-Stokes theorem, Primitive equations, tropopause fold, stratosphere-troposphere interaction, Lower and middle atmospheres- annual oscillations, quasi biennial oscillation

Unit II: Atmospheric Thermodynamics and Radiative transfer (L 15, Marks 15)

Ideal gas law for the atmosphere, Dalton's law of partial pressure-mean molecular weight of dry and moist air, equation of state for the atmosphere, the first law of thermodynamics and applications- isothermal, isochoric, isobaric transformation, adiabatic transformation, entropy and potential temperature, parcel concept, atmospheric stability, Brunt Vaisala frequency, moisture in the atmosphere- latent heat, Clausius-Clapeyron's relation, lifting condensation level

Radiative transfer: Introduction to radiative transfer, radiative transfer equation, Beer-Bougher-Lambert law, Schwarzschild's equation and solution, equation of radiative transfer for plane-parallel atmosphere and for 3D inhomogeneous media, Scattering of solar radiation: Rayleigh and Mie scattering

Unit III: Atmospheric composition and climate change (L 15, Marks 15)

Gas Chemistry: stratospheric ozone chemistry- Chapman cycle, limitations of Chapman model, ozone photolysis, ozone distribution, heterogeneous reaction, HOx, NOx, CLOx cycles, ozone hole; Tropospheric ozone chemistry

Aerosols: optical, physical properties, and radiative properties, chemical composition, size distribution, vertical distribution, types, direct and indirect effects

Climate Change: Causes- natural versus anthropogenic-role of trace gases and aerosols, impacts, introduction to a climate model

Unit IV: Atmosphere of other solar system planets (L 15, Marks 15)

Physical properties, chemical composition of planetary atmospheres of the solar system planets, clouds and water escape, dust storms-martian dust devils, difference between Terrestrial and Jovian planets, difference between gas and ice giants, density and size differences, rings in jovian planets, weather and volcanic activities on Jovian planets, tidal heating, satellite missions

In Semester: 40

Assignment /Presentation/ attendance/ Classroom interaction/quiz etc.: 20

Written Test: 20

End Semester:

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

This course will enable the students to

1. Acquainted with the thermodynamics and dynamics of the earth's atmosphere.
2. Chemistry of the troposphere and stratosphere.
3. Develop simple models of the atmosphere.
4. Understand the physico- optical and radiative properties of aerosols and climate implications.
5. Familiarize the atmospheres of other solar system planets.

Suggested Readings:

1. Meteorology for Scientists and Engineers, R Stull, Brooks/Cole, Thomson Learning

2. Atmospheric Chemistry and Physics, J H Seinfeld and S N Pandis, John Wiley and Sons

3. Introduction to Atmospheric Physics, D G Andrews, Cambridge University Press

4. Fundamentals of Atmospheric Modeling, M Z Jacobson, Cambridge University Press

5. An Introduction to Atmospheric Radiation, K N Liou, Academic Press

6. Stratosphere-Troposphere Interaction - K Mohankumar, Springer

7. The Atmosphere: An Introduction to Meteorology, F K Lutgens and E J Tarbuck, Prentice Hall

8. *The Atmosphere and Climate of Mars* - Haberle, R., Clancy, R., Forget, F., Smith, M., & Zurek, R. (Eds.). (2017), Cambridge: Cambridge University Press 9. MARS: AN INTRODUCTION TO ITS INTERIOR, SURFACE AND ATMOSPHERE - Nadine Barlow, Cambridge University Press

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Course Code: PH-DSE-IIIE
Course Title: Astrophysics and Cosmology I
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

At the completion of this course, a student will be able to

1. Understand various properties of stars.
2. Understand the mechanism of energy transport, formation and evolution of stars.
3. Get an idea about the galaxies and the methods of large scale distance measurements.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Stars (L 20, Marks 20)

Properties of stars: luminosity, surface temperature, mass and their correlations; stellar structures: structure equations, Newtonian theory of equilibrium, polytropic gas spheres, Lane-Emden equation; mean molecular weight, Saha's ionization theory, spectral classification, Hertzsprung-Russel diagram; variable stars, star clusters.

Unit II: Energy Transport (L 10, Marks 10)

Various mechanisms of energy transport in stars, stellar opacity, Rosseland mean opacity, equation of radiative transfer, thermodynamics of radiation; radiative processes in astrophysics.

Unit III: Stellar Evolution (L 10, Marks 10)

Star formation, Jeans criteria, various stages of nuclear burning; compact objects: white dwarf, neutron stars (pulsars) and black holes.

Unit IV: Galaxies and Distance Measurement (L 20, Marks 20)

Hubble's classification, active galaxies: starburst galaxies, Seyfert galaxies, active galactic nuclei, supermassive black holes, quasars, blazars; cosmic distance ladder: trigonometric parallax, Cepheid variables, mean sequence fitting, Tully-Fisher relation, supernovae and gravitational lensing.

Mode of Assessment/ Assessment Tools (%)

In Semester:	**40**	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:		20
Written Test:		20
End Semester:	**60**	
Written Test:		60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

After the completion of this course, it is expected that this course will

1. Enable a student to acquire the basic of the stellar properties, energy transport and evolution.
2. Enable a student to acquire the basic of the galaxies and their formation and related distance measurements.
3. Prepare a student for advanced topics in astrophysics and cosmology.
4. Motivate a student to pursue a career in a field of astrophysics and cosmology.

Suggested Readings:

1. An Introduction to the Study of Stellar Structure - S. Chandrasekhar (Dover Publication).
2. General Relativity and Cosmology - Banerji and Banerjee (Elsevier).
3. An Introduction to Cosmology - J.V. Narlikar (Cambridge University Press).
4. An Introduction to Astrophysics - B. Basu (Prentice-Hall of India).
5. Astrophysics : Stars and Galaxies - K. D. Abhyankar(Orient Longman).
6. Stars and Galaxies - Michael A. Seeds (Thomson Learning).
7. Cosmic Perspective - Bennettt, Donahue, Schneider and Voit (Pearson Addision Wesley).

Course Code: PH-DSE-IIIF
Course Title: Physics of Black Holes
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

(a) To introduce the learners with the fascinating world of black holes.
(b) To enable the learners in developing ideas about the theory of black holes.
(c) To update the learners about recent developments in black hole physics.
(d) To motivate students to pursue research in black holes..

Unit wise distribution of course contents with unit wise distribution of weight age and contact hours:

Unit I: (L-5, Marks-5)

Introduction and motivation: Gravitational collapse, The Chandrasekhar limit, Neutron stars, Black holes in Newtonian gravity, Black holes in General Theory of Relativity, Significance of studying black holes.

Unit II: (L-20, Marks-20)

The Schwarzschild black hole : Test particles: geodesics and affine parameterization. Symmetries and killing vectors, Spherically symmetric pressure free collapse, Carter-Penrose diagrams, the event horizon, black holes vs. naked singularities.

Unit III: (L-20, Marks-20)

Charged black holes: Reissner-Nordstrom, Cauchy horizons, Istropic coordinates for RN.

Rotating black holes: Uniqueness theorem, The Kerr solution, angular velocity of the horizon, the Ergosphere, The Penrose process: Limits to energy extraction, Super radiance.

Energy and angular momentum: Covariant formulation of charge integral, ADM energy, Komar integrals, Energy conditions.

Unit IV: (L-15, Marks-15)

Black hole mechanics: Laws of black hole mechanics: Zeroth law, Smarr's formula, First law, Second law, Hawking radiation, black hole thermodynamics.

Mode of Assessment/ Assessment Tools (%)

In Semester:	**40**	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:		20
Written Test:		20
End Semester:	**60**	
Written Test:		60

(Equal weightage to be assigned to each credit)

<u>Expected Learning Outcomes :</u>

After completion of this course, it is expected that:

(a) The learners will understand the basic concepts and ideas in black hole physics.
(b) To learners will develop fundamental ideas about charged and rotating black holes.
(c) The learners will be aware of recent developments in black hole physics.
(d) To learners will be well prepared to pursue research in black hole physics.

Suggested Readings:

1. Lecture Notes on **Black Holes** by **P.K. Townsend,** arxiv:gr-qc/9707012.
2. **Gravitation and Cosmology** *by* **S. Weinberg,** Wiley Publications.
3. Lecture Notes on **General Relativity** by **David Tong,** Cambridge University.
4. Lecture Notes on **Cosmology** by **David Tong,** Cambridge University.

Course Code: PHYSICS-DSE-IVA
Course Title: High Energy Physics II
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:

At the completion of this course, a student will be able to

1. Use the formulation of quantum field theory in a number of fields.
2. Apply the concepts of quantum field theory to quantum electrodynamics.
3. Explain the physics of fundamental particles and their interactions.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Quantum Field theory (L 25, Marks 25)

Concept of field and quantization, Lagrangian of a field, Schwinger's action principle, Fock space states and their eigen values, method of second quantization, canonical quantization of scalar, vector and spinor fields, energy, momentum and charge of the field, vacuum in field theory, propagators; C, P, T transformation properties of scalar and vector fields.

Unit II: Quantum Electrodynamics (L 20, Marks 20)

S-matrix, covariant perturbation theory, path integral formalism, Feynman diagram (rules in momentum space), Wicks theorem, calculation of second order process, electron interaction with electromagnetic field, Mott scattering, Compton scattering (Klein-Nishima formula), Møller scattering, Bhaba scattering, bremsstrahlung, vacuum polarization, self-energy of electron.

Unit III: Particle Interactions (L 15, Marks 15)

Fundamental interactions (electromagnetic, weak, strong and gravitational) and their characteristics, conservation laws and decay modes, charged leptonic weak interactions, decays of muon, neutron and charged pions, neutral weak interactions, Fermi theory of weak interaction, V-A interaction, Cabibbo angles, weak mixing angles, CP violation, CPT theorem.

Mode of Assessment/ Assessment Tools (%)

In Semester:	**40**
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester:	**60**
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

After the completion of this course, it is expected that this course will

1. Enable a student to acquire the basics of quantum field theory and realize its importance.
2. Enable a student to apply the framework of field theory to quantum electrodynamics.

3. Prepare a student for advanced topics in field theory and particle physics.
4. Motivate a student to pursue a career in high energy physics.

Suggested Readings:

1. Introduction to Elementary Particles, D. J. Griffiths (John Wiley & Sons).
2. Quarks and Leptons, Francise Halzen and Alan D. Martin (John Wiley & Sons).
3. Introduction to High Energy Physics, Donald H. Perkings (Cambridge University Press).
4. Gauge Theory of Elementary Particle Physics, T. P. Cheng and L.F. Li (Oxford Univ. Press).
5. Physics of Elementary Particles, H. Muirhead (Pergamon Press).
6. Quantum Field Theory, Lewis H. Ryder (Cambridge University Press).
7. An Introduction to Quantum Field Theory, M. E. Peskin and D.V. Scroeder (Levant Books).
8. Field Quantization, W. Greiner and J. Reinhardt (Springer).
9. A First Book of Quantum Field Theory, A. Lahiri and P.B. Pal (Narosa).
10. QFT Lecture Notes I and II, David Tong (Cambridge University).

Course Code: PH-DSE-VA
Course Title: High Energy Physics III
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:
At the completion of this course, a student will be able to
(1) Explain the basics of gauge theories.
(2) Analyze symmetry breaking in gauge theories.
(3) Apply the knowledge of gauge theory to QCD.
(4) Outline a number of areas in beyond the standard model physics.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Gauge Theories (L 15, Marks 15)
Noether's theorem, gauge theories of interactions, gauge symmetries (global and local), Abelian and non-Abelian gauge theories (Yang-Mills theories).

Unit II: Symmetry Breaking in Gauge Theories (L 20, Marks 20)
Spontaneous symmetry breaking, Goldstone theorem and Goldstone bosons, Higgs mechanism and Higgs boson, electro-weak theory (Salam-Weinberg-Glashow theory), favour-conserving neutral-current process, weak mixing angle (GIM mechanism), standard model, LHC and Discovery of Higgs boson.

Unit III: Quantum Chromodynamics (QCD) (L 20, Marks 20)

Hadron production in e^-e^+ annihilation ($e^-e^+ \rightarrow qq$) , fragmentation functions and their scaling properties, concepts of form factors and charge radii, deep-inelastic scattering and structure functions, parton model, Bjorken scaling and its violation, asymptotic freedom, gauge theory of quark-quark interactions, lattice gauge theory and color confinement, quark-gluon plasma.

Unit IV: Physics Beyond Standard Model (elementary ideas) (L 5, Marks 5)
Particle physics cosmology interface, grand unified theories (GUTs) and proton decay possibilities, supersymmetry and minimal supersymmetric standard model (MSSM), neutrino oscillation and neutrino mass, magnetic monopoles, solitons, instantons, string and superstring theories, extra dimensions.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
After the completion of this course, it is expected that this course will
(1) Enable a student to acquire the basic knowledge of gauge theories.
(2) Enable a student to familiarize with the standard model.
(3) Prepare a student for advanced topics in field theory and particle physics.
(4) Motivate a student to pursue a career in high energy physics.

Suggested Readings:

1. Introduction to Elementary Particles, D. J. Griffiths, John Wiley & Sons.
2. Quarks and Leptons,FranciseHalzen and Alan D. Martin, John Wiley & Sons.
3. Introduction to High Energy Physics, Donald H. Parkings, Cambridge University Press.
4. Gauge Theory of Elementary Particle Physics, T.P.Cheng and L.F. Li, Oxford Univ. Press.
5. Physics of Elementary Particles, H. Muirhead, Pergamon Press.
6. Quantum Field Theory, Lewis H. Ryder, Cambridge University Press.
7. An Introduction to Quantum Field Theory, M. E. Paskin and D.V. Scroeder, Levant Books.
8. Field Quantization, W. Greiner and J. Reinhardt, Springer.
9. A First Book of Quantum Field Theory, A. Lahiri and P.B. Pal, Narosa.
10. QFT Lecture Notes I and II, David Tong, Cambridge University.

Course Code: PH-DSE-IVB
Course Title: Condensed Matter Physics II
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objective:

1. The course will provide basic knowledge on Lattice vibration and some properties of solid related to lattice vibration.
2. It will develop the basic knowledge of the thin film Physics. It will provide the knowledge of preparation and characterization of thin films and its application in devices.
3. It will enhance the knowledge on semiconducting properties and optical effect in semiconductors.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Lattice vibrations (L 15, Marks 15)
Harmonic approximation, monatomic and diatomic linear lattices, dispersion relations, normal modes, Phonons, infrared absorption in ionic crystals, lattice dynamics in three dimensions (harmonic& adiabatic approximation), Normal modes of a monatomic 3-dimensional Bravais lattice.
Quantum theory of harmonic crystal, lattice specific heat, anharmonic effects, thermal expansion, the Grueneisen parameter, normal and umklapp processes.

Unit II: Thin films (L 20, Marks 20)
Introductory concepts, methods of preparation of thin films (vacuum evaporation, chemical vapour deposition, sputtering), thickness determination, conductivity of thin films, effect of thickness on transport properties, Thomson's theory and Fuch's theory, elementary concepts of surface crystallography, surface structure analysis of thin films (SEM, TEM and AFM)

Unit III: Semiconductors (L 10, Marks 10)
Introductory Concepts, Rectifying properties of barriers, Schottky theory of M.S contact, surface states, p-n junction rectifiers
Photovoltaic device principles, solar cell, temperature effect, solar cell materials, efficiency.

Unit IV: Optical Properties (L 15, Marks 15)
Optical and high frequency effects in semiconductors, optical constants, free carrier absorption, fundamental absorption, direct and indirect transitions.
Electronic interband and intraband transitions, relation between optical properties and band structure, optical constants, luminescence.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

1. The students will be able to use the knowledge in fabrication of different thin film semiconductor devices.
2. The students will be able undertake some research or project work on semiconducting thin film device.

Suggested readings:

1. Introduction to Solid State Theory, O. Madelung, Springer-Verlag
2. Quantum Theory of Solid State, J Callaway, Academic Press
3. Theoretical Solid State Physics, A. Huang, Elsevier
4. Handbook of Thin Film Technology, Michelle and Glang, McGraw Hills
5. Semiconductors, R.A. Smith, Cambridge university Press
6. Thin Film Fundamentals, A. Goswami, New Age International
7. Physics of Semiconductor Devices, S. M. Sze, Wiley

Course Code: PH-DSE-VB
Course Title: Condensed Matter Physics Laboratory
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Lab – 04

Course Objectives:

At the completion of this course, a student will be able to

1. Gather a broader knowledge on the experimental techniques of solid state Physics
2. Understand the basic concepts in hands on mode through the basic solid state physics experiments.

List of Experiments:

1. To Determine the Lange g-factor by Electron Spin Resonance Method
2. To determine the Curie temperature of phase transition for (a) ferroelectric materials and (b) for ferrites
3. To determine the Boltzmann Constant.
4. To determine the Stefan's Constant.
5. To determine the Neel temperature of an anti-ferromagnetic material by Gouy's method.
6. To prepare and measure the thickness of a thin film.
7. To study the thermo luminescence of an F-center.
8. To study the X-ray diffraction using powder photography.
9. To study the Hall Effect and determine the different parameters.

Mode of Assessment/ Assessment Tools (%)

In Semester: **40**

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Viva Voce:	20

End Semester: 60

Laboratory experiments:	60

(One experiment from the list of experiments to be performed)

Expected Learning Outcome:

The course will

1. Equip a student with different experimental techniques used for determination of various properties of solids.
2. Enhance the laboratory skill of a student which will help a student to experimental research work in the area.
3. Enable a student to understand the subject in some more detail.

Suggested readings:

1. Introduction to Solid State Physics, C. Kittel, John Wiley & Sons
2. Solid State Physics, A. J. Dekker, Macmillan India Ltd
3. Thin Film fundamentals,PallavChowdhury, New Age International

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Course Code: PHYSICS-DSE-IVC
Course Title: Communication Electronics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory-04

Course Objectives:
At the completion of this course, a student will be able to
1. Understand the basic techniques of electronic communication like modulation, multiplexing etc.
2. Apply the knowledge to understand the current generation communication technologies.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Information theory: (L 8, Marks 8)
General Binary Signaling, Coherent Receivers for Digital Carrier Modulations, General Expression for Error Probability of optimum receivers.
Information Theory**:** Measure of Information, Source Encoding, Entropy, Channel capacity, Error Correcting codes: Hamming code, linear block codes, cyclic codes, Huffman coding, Shannon-Fano coding, code tree & Trellis diagram.

Unit II: Digital modulation techniques (L 10, Marks 10)
Concept of bit rate, baud, bandwidth, ASK, FSK, BPSK, QPSK, 8PSK, 16PSK, QAM, probability of error and bit error.

Unit III: Spread spectrum and Multiple accessing (L 6, Marks 6)
Frequency hopping, DSSS.CDMA, TDMA, FDMA

Unit IV: Microwave Communication (L 10, Marks 10)
Loss in free space, microwave frequencies and bands, propagation of microwaves, effective height of antenna in LOS communication, field strength of tropospheric waves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources.

Unit V: Antennas (L 7, Marks 7)
Basic antenna theory, beam-width, directivity, antenna efficiency, gain, Hertzian dipole, dipole arrays, folded dipole, log-periodic antenna, UHF and microwave antennas, microstrip antenna, Beamforming and MIMO concept scattering parameters and their measurements, vector network analyzer,

Unit VI: Radar Systems (L 5, Marks 5)
Radar block diagram and operation, radar frequencies, pulse considerations, radar range equation and derivation, pulsed and CW radar, minimum detectable signal, pulse repetition frequency.

Unit VII: Cellular Communication (L 7, Marks 7)
Cell splitting, frequency reuse, roaming and hand off, architecture of cellular mobile communication network, AMPS, IS, GSM system of communication, GPRS, EDGE, 3G and 4G systems, introduction to 5G.

Unit VIII: Satellite Communication (L 6, Marks 6)
Satellite orbits, geostationary satellites, antenna look angles, frequency allocations, satellite system link models, up link, down link, cross link, transponders, satellite system parameters, satellite system link equation.

Mode of Assessment/ Assessment Tools (%)
In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
This course will enable the students to
1. Identify the basic techniques of communication like modulation, multiplexing.
2. Analyze the modulations schemes and their applicability.
3. Analyze present generation systems related to microwave communication, cellular communications, satellite communication.

Suggested Readings:

1. Advanced Electronic Communication Systems, W. Tomasi, Pearson Education India.
2. Principles of electronic communication systems, L E Frenzel, McGraw Hill Education
3. Electronic Communication Systems, G. Kennedy, McGraw Hill Education
4. Microwave Devices and Circuits, S Y Liau, Pearson Education India.
5. Introduction to RADAR Systems, M Skolnik, McGraw Hill Education.
6. Data and Computer Communications, W. Stallings, Pearson Education India
7. Antenna and Wave Propagation, J D Kraus, McGraw Hill Education

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Course Code: PH-DSE-VC
Course Title: Electronics Lab
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Lab-04

Course Objectives:

1. To allow students to learn the electronic principles using hands-on philosophy
2. To allow students to design small analog circuit systems like small signal amplifier, filter comparator etc.
3. To allow students to apply their knowledge for assembly language programming to do arithmetic operations and make small data processing software.
4. To introduce students to use microprocessor and microcontroller to interface peripheral devices
5. To introduce students to radiation pattern of antenna through measurement.
6. To introduce students to optical electronics components and measurements.

List of experiments to be performed:

Guidelines: 80% experiments needs to be performed for claiming 4 credits. All analog experiments except the antenna radiation patter are to be assembled by the students in either breadboard or PCB.(No-Kit allowed for analog experiments). Each student will use Simulation software like Simulink for designing the analog circuits. The design parameter for each student would be decided by the course teacher and the students final circuit needs to perform as per the design specification. Microprocessor/microcontroller experiments can be conducted using pre-assembled kits but each student is required to write one unique program for passing the course.

1. To design a two stage small signal amplifier using transistor or OPAMP for a gain of 10/15/20 etc for a bandwidth of 10/50/100KHz.
   Additional experiments: Use Darlington pair/bootstrapping to improve input impedance

2. To design a Schmitt trigger comparator for given LTP and UTP (e.g. 2V/3V, 1V/4V etc) using OPAMP and comparator IC.

3. To use 8085 kit for arithmetic operations like addition, subtraction, division, multiplication, factoring etc. One additional experiments to be given to each students to

judge his learning like (a) Calculation of factorial (b) Sorting of 5 numbers in ascending and descending order (c) Generate 1 or 2 sec delay etc.

4. To study the radiation pattern of various types of Yagi antenna elements using different number of director and reflector elements at different distances between transmitter and receiver.

5. To use 8051 kit for arithmetic operations like addition, subtraction, division, multiplication, factoring etc. One additional experiments to be given to each students to judge his learning like (a) Calculation of factorial (b) Sorting of 5 numbers in ascending and descending order (c) Look-up table creation etc.

6. Study and characterization of single mode and multi-mode of optical fiber.

7. Measurement of optical fiber numerical aperture

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Viva Voce:	20
End Semester: 60	
Laboratory experiments:	60
(One experiment from the list of experiments to be performed)	

Expected Learning Outcome

The student will be able to

1. Design small electronic circuits
2. Write assembly language program to do arithmetic, logical and data processing operations
3. Analyze antenna radiation pattern and characteristics for real life application
4. Understand the working of optical electronics components

Course Code: PH-DSE-IVD
Course Title: Space Physics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory-04

Objective of the course is to

1. Introduce the Physics of the Earth's ionosphere

2. Introduce measurement techniques and space applications
3. Introduce the Physics of the Sun and space weather.
4. Introduce radio astronomy

Unit I: Physics of the Ionosphere (L 18, Marks 18)

Introduction to atmospheric stratifications, Discovery of ionospheric layers, principle of formation, Chapman's hypothesis of ion production, ionization by EUV and energetic particles, Loss process: chemical recombination, alpha and beta Chapman, vertical transport and diffusion, Formation of D, E, and F1 and F2 layers, morphological features of equatorial/low and middle latitude ionosphere, local time, seasonal and solar cycle variations, brief idea of magnetosphere and planetary ionospheres.

Unit II: Ionosphere measurement techniques (L 18, Marks 18)

In situ and remote measurement techniques-Langmuir probe, ionosonde, radar systems, radio occultations, ellipse geometry and definition of orbit terms/elements, co-ordinate systems, different orbits: Keplerian orbits, polar, sun synchronous, geosynchrnous, and geostationary, Molniya orbits, LEO, MEO, GEO etc. atmospheric effect on satellite, satellite navigation and positioning, GPS/GNSS/IRNSS systems. Models of the ionosphere : IRI, SAMI2 etc.

Unit III: Physics of the Sun and its interactions (L 12, Marks 12)

Structure of the Sun, solar wind, solar wind formation in the corona, magnetosphere of earth, solar wind interaction with the magnetosphere, solar cycle, solar flares, CME, Geomagnetic effects, study of solar phenomena from L1 point.

Unit IV: Radio Astronomy (L 12, Marks 12)

Introduction to RA and difference from optical astronomy, Cosmic microwave background: discovery, power, spectral power, brightness, discrete radio sources, flux density, radio sky, galactic radio noise, radio sources, Fundamentals of radio telescopes, break down of a radio telescope, interferometry, Array telescopes: Giant Metre-wave Radio Telescope (GMRT), Event Horizon Telescope.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester:60 (written test)

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

After the completion of this course the student will be able to

1. Understand the basics in the Earth's ionosphere and its drivers.

2. Acquainted with space science and its applications.

3. Learn about space weather threat Solar wind, CME, solar wind interaction with the magnetosphere.

4. Understand the fundamentals of radio astronomy.

Suggested Readings:

1. Earth's Ionosphere, Plasma Physics and Electrodynamics, M C Kelley, Academic Press

2. The Solar Terrestrial Environment, J K Hargreaves, Cambridge University Press

3. Introduction to Ionospheric Physics, Henry Rishbeth and Qwen K. Garriott, Academic Press.

4. Space Plasma Physics, A C Das, Narosa Publishing House

5. Radio Astronomy, J D Kraus, McGraw Hill

Course Code: PH-DSE-VD
Course Title: Space Physics Lab
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Lab-04

Course Objectives:

1.

Lists of Experiments:

1. Measurement of Ozone using a Microtops II Ozonometer and comparison with satellite observations.
2. Measurement of Aerosol Optical Thickness using a Microtops II Sunphotometer.
3. Study of Aerosol Optical Depth using a Multi Wavelength Radiometer.
4. Measurement of Aerosol Elemental (Black) Carbon using an Aethalometer.
5. Study of temporal and spatial variation of foF2 in the Indian zone ionosphere.
6. Measurement of Total Electron Content at Dibrugarh using a GPS TEC and Scintillation Monitor.
7. Study of the temporal variation of Electron Density over Dibrugarh using a Canadian Advanced Digital Ionosonde.
8. Measurement of Toxic gases using a DirectSense Toxic gas monitoring kit.
9. Measurement of Surface ozone using 2B Tech Surface Ozone Monitor.
10. Measurement of Radiative forcing at Dibrugarh using the SBDART model.
11. Development of Simple Models of the Atmosphere.
12. Study of the variations in the earth's magnetic field.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Viva Voce:	20
End Semester: 60	
Laboratory experiments:	60
(One experiment from the list of experiments to be performed)	

Course Code: PH-DSE-IVE
Course Title: Astrophysics and Cosmology II
Nature of the Course: DSE
Total Credit Assigned: 4
Distribution of credits: (L 4)

Course Objectives:
At the completion of this course, a student will be able to
1. Understand clearly the GTR and its range of applications.
2. Apply the concept of GTR to solve problems of astrophysics and cosmology.
3. Get a clear view on the present and early states of the universe, and related unsolved issues.
4. Understand the basics and necessities of the modified theories gravity.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: General Theory of Relativity (GTR) (L 20, Marks 20)

Principle of equivalence, general covariance, spacetime metric, geodesic equation, gravity as curvature of spacetime, Bianchi identities, energy momentum tensor, Einstein's field equations, Newtonian approximation, Schwarzschild solution, Birkhoff's theorem, Kruskal-Szekeres coordinates, Kerr metric and rotating black holes.

Unit II: Prediction and applications of GTR (L 12, Marks 12)
Bending of light, gravitational red-shift, precession of perihelion of Mercury; gravitational lensing, gravitational waves; astrophysical application: neutron stars, Oppenheimer-Volkov equation.

Unit III: Cosmology (L 20, Marks 20)
Einstein's universe, de Sitter solution, expanding universe, cosmological principles, Robertson-Walker (RW) metric, kinematics of RW metric, Hubble's law, luminosity distance, Friedmann equations, Hot Big Bang model, radiation era, matter-radiation decoupling, CMBR, Steady State Theory, Quasi Steady State Cosmology (introductory discussion only), dark matter, accelerating universe, dark energy (cosmological constant, quintessence, phantom field), alternative theories of gravity.

Unit IV : Early Universe (L 8, Marks 8)
Limit of classical cosmology, Planck era, inflation, scalar fields, baryon asymmetry, big-bang nucleosynthesis, topological defects.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
After the completion of this course, it is expected that this course will
1. Enable a student to acquire the basics of GTR, theories of its beyond, and cosmology.
2. Enable a student to think about the outstanding issues of astrophysics and cosmology.
3. Prepare a student for advanced topics in astrophysics and cosmology.
4. Motivate a student to pursue a career in any field of astrophysics and cosmology.

Suggested Readings:

1. An Introduction to Cosmology - J. V. Narlikar (Cambridge University Press).
2. Gravitation and Cosmology - S. Weinberg (John Wiley & Sons).
3. General Relativity and Cosmology - S. Banerji and A. Banerjee (Elsevier).
4. General Relativity and Cosmology - S. K. Srivastava (Prentice-Hall of India).
5. Astrophysics : A Modern Perspective - K. S. Krishna Swamy (New Age International Publisher).

6. Gravity : An Introduction to Einstein General Relativity - James B. Hartle (Pearson Education)
7. General Theory of Relativity - P. A. M. Dirac (Prentice-Hall of India).
8. Principles of Cosmology and Gravitation - M. V. Berry (Overseas press).
9. Cosmology - S. Weinberg (Oxford University Press).
10. Modern Cosmology - Scott Dodelson (Academic press).

Course Code: PH-DSE-IVF
Course Title: String Theory
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory-4

Course Objectives:

(e) To introduce the learners with the fascinating world of string theory.
(f) To enable the learners in developing ideas about quantum theories of gravity.
(g) To update the learners about recent developments in beyond the standard model physics.
(h) To motivate students to pursue research in string theory.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: (L-15, Marks-15)

Introduction to relativistic string: Introduction to string theory and its significance, the relativistic point particle: quantization, Ein Einbein. The Nambu-Goto action: symmetries of Nambu Goto action, equations of motion. The Polyakov action: Symmetries of the Polyakov action, Fixing a gauge. Mode expansions.

Unit II: (L-20, Marks-20)

The quantum string: Covariant quantization: ghosts, constraints. Lightcone quantization: Lightcone gauge, quantization. The string spectrum: the tachyon, the first excited states, higher excited states. Lorentz invariance. A node to the superstring.

Unit III: (L-15, Marks-15)

Open strings and D-Branes: Quantization: the ground state, first excited states: a world of light, higher excited states and Regge trajectories, another node to the superstring. Brane dynamics: The Dirac action. Multiple branes: a world of glue.

Unit IV: (L-10, Marks-10)

Introducing AdS-CFT Correspondence: Basics of AdS space and conformal field theory, The correspondence and its dictionary, Large N Gauge theory, Maldacena duality, ABJM duality, Applications of AdS-CFT: hydrodynamics, holographic superconductors, AdS-CMT, SYK Model.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Examination: 20
End Semester: 60
Written Examination: 60
(One experiment from the list of experiments to be performed)

<u>**Expected Learning Outcomes :**</u>

After completion of this course, it is expected that:

(a) The learners will understand the basic concepts and ideas in string theory.
(b) The learners will develop fundamental ideas about quantum gravity.
(c) The learners will be aware of recent developments in string theory and its applications.
(d) The learners will be well prepared to pursue research in string theory.

Suggested Readings:

1. Lecture Notes on **String Theory** by **David Tong,** University of Cambridge.
2. **String Theory** *by* **J. Polchinski,** Cambridge University Press.
3. **Superstring Theory** *by* **M. Green, J. Schwarz and E. Witten,** Cambridge University Press.
4. **A First Course in String Theory** *by* **B.Zwiebach,** Cambridge University Press.
5. **Introduction to AdS-CFT** *by* **L. Nastase,** arxiv:hep-th/0712.0689
6. Lecture Notes on **Holographic Methods for Condensed Matter Physics** by **S.A. Hartnoll,** arxiv:hep-th/0903.3246

ABILITY ENHANCEMENT COURSES

Course Code: PH-AEC-IA
Course Title: Experimental Techniques
Nature of the Course: AEC
Total Credit assigned: 2
Distribution of Credit: (Lecture + Practical/ Tutorial)

Course Objectives:
At the completion of this course, a student will be able to
1. Understand the basic concepts of errors in measurements and techniques of data analysis.
2. Understand the principle of sensors and transducers and OPAMP

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Data analysis techniques (L 8, Marks 8)
Data interpretation and analysis. systematic and random errors in measurement, expression of uncertainty, propagation of errors, Precision and accuracy, Error analysis, least squares fitting, Linear and nonlinear curve fitting, chi-square test

Unit II: Transducers, Sensors and detectors (L 12, Marks 12)
Resistive (Potentiometer, Strain Gauge-Theory, types, temperature compensation and applications), Capacitive (Variable Area Type-Variable Air Gap Type-Variable Permittivity type) and Inductive (LVDT). Measurement of displacement and velocity (translation and rotational), Particle Detectors-Ionization chamber and Geiger Muller counter.

Unit III: Electronic instrumentation (L 10, Marks 10)
Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), Fourier transforms (spectrum analyzer), lock-in detector.

Mode of Assessment/ Assessment Tools (%)
In Semester: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test: 10
End Semester: 30
Written Test: 30
(Equal weightage to be assigned to each credit)
Expected Learning Outcome:
This course will enable the students to
1. Identify the errors in measurement.
2. Analyze the working of various sensors and transducers.

Suggested Readings:

1. Instrumentation, Measurements and Analysis by BC Nakra and KK Choudhary, McGraw Hill Education India Pvt. Ltd.
2. Electronic Instrumentation and Measurement Techniques by W.D. Cooper and A. D. Helfrick,, Prentice-Hall .
3. Electronic Instrumentation by H. S. Kalsi, Tata McGraw Hill.
4. Nuclear Radiation Detectors, by S.S. Kapoor, V. S. Ramamurthy, Wiley-Eastern Limited, Bombay)

Course Code: PH-AEC-IB
Course Title: Observational Astronomy
Nature of the Course: AEC
Total Credit assigned: 2
Distribution of Credit:Theory-2

Course Objectives:
1. Introduction to observational astronomy.
2. Coordinate systems, telescopes and observational instruments (CCDs, filters, spectrographs)
3. Observational methods and techniques.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Fundamentals of Astronomy (L-15, Marks 15)
Introduction to astronomy and astrophysics, stellar luminosity (apparent and absolute) and surface temperature, spectral classification, mass and their correlations, Hertzsprung-Russell diagram

Unit II: Distance Measurements and Observational Techniques (L-15, Marks 15)
Trigonometric parallax, magnitude system and scale, celestial coordinates, concept of time, astronomical telescopes, photometry, spectrophotometry, Modern image processing devices, multi wavelength astronomy (radio, x-ray, gamma-ray).

Mode of Assessment/ Assessment Tools (%)

In Semester:	20	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:		10
Written Test:		10
End Semester:	30	
Written Test:		30

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
On successful completion of this course, students should be able to:

1. Develop the knowledge of handling telescopes and other modern image processing devices.
2. Describe the effects of the properties of light and Earth's atmosphere on astronomical observations, coordinate system for stars
3. Acquire the knowledge of photometry and multi wave astronomy

Recommended Readings

1. Observational Astronomy, D. Scott Birney, Cambridge University Press.
2. The Cosmic Perspective,J. Bennettt, M. Donahue, N. Schneider and M.Voit, Pearson Addison Wesley.
3. An Introduction to Astrophysics, B. Basu, Prentice-Hall of India.
4. Astrophysics: Stars and Galaxies, K. D. Abhyankar, Orient Longman.
5. Spherical Astronomy, F. Brunnow, Van Nostrand.
6. Practical Astronomy, George L. Hosmer, John Wiley and Sons.

Course Code: PH-AEC-IIA
Course Title: Nano-Structured Materials
Nature of the Course: AEC
Total Credit assigned: 2
Distribution of Credit: Theory-2

Course Objectives:

The aim of the course is to

1. Provide a systematic coverage and insight into the promising area of nano materials in order to facilitate the understanding of the nature and prospects for the field.
2. Discuss about various types of nanomaterials with specific examples of semiconducting nanomaterials in various dimensions and carbon based nanomaterials, viz., fullerene and carbon nanotubes
3. Provide information about various synthesis and characterization techniques of nanomaterials
4. Discuss wide applications of nanomaterials

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: (L 10, Marks 10)

Introduction to nano-science and technology, history and scope, interdisciplinary nature, surface to volume ratio, electronic structure.

Types of nanomaterials, semiconducting nanomaterials: quantum dot, quantum wire, quantum well, idea of band structure, density of states, variation of density of state and band gap with crystal size, electron confinement in one, two and three dimensions, carbon nanomaterials: fullerene, carbon nanotube.

Unit II: (L 10, Marks 10)

Chemical and physical methods for synthesis of nanostructured materials, Applications of nanostructured materials.

Unit III: (L 10, Marks 10)
Nanomaterials characterization, instruments, principle of measurements, measurement techniques: X-ray diffraction, scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, optical and vibrational spectroscopy.

Mode of Assessment/ Assessment Tools (%)

In Semester: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test: 10
End Semester: 30
Written Test: 30
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

This course will enable the students to

1. Know the underlying principles governing the fascinating behavior of nanomaterials
2. Gather knowledge about some of the modern promising nanomaterials such as quantum dots, carbon nanotubes etc.
3. Learn the various methods for synthesis and characterization of nanomaterials as well as their wide variety of applications

Suggested readings:

1. Updated materials/notes on individual topics will be provided during classes.
2. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley–Interscience.
3. Nano: The Essentials, T. Pradeep, McGraw Hill Education (India) Private Limited
4. Textbook of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday, Universities Press-IIM

Reference Book:
1. Encyclopedia of Nanoscience and nanotechnology, Edited by Hari Singh Nalwa.

Course Code: PH-AEC-IIB
Course Title: Vacuum Techniques
Nature of the Course: AEC
Total Credit assigned: 2
Distribution of Credit: Theory-2

Course Objectives:
To introduce the theory of vacuum to the students.

1. Comprehension of thermal and flow behaviour of gases at very low pressures.

2. Methods of achieving and measurement low pressures. Vacuum pumps and vacuum meters.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: (L 15, Marks 15)
Production of Vacuum: Different types of vacuum pumps, Rotary pump, diffusion pump cryogenic pumps, cryosorption pumps, getter pump.
Vacuum materials: Absorption of gases, out gassing of materials, out gassing rates of vacuum materials, the permeation process, permeability of vacuum materials.

Unit II:(L 15, Marks 15)
Vacuum assembly techniques: Design and performance of high vacuum system.
Vacuum measurements: Leak detection, pressure measurements (McLeod, Pirani, Penning gauge), residual gas analysis, Bayard-Albert partial gas analysis, mass spectrometers.

Mode of Assessment/ Assessment Tools (%)

In Semester: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test: 10
End Semester: 30
Written Test: 30
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
Students will be able to:
1. Recognize the importance of vacuum in modern technology and research.
2. Basics of kinetic theory of gases, pressure, particle collisions, velocity and free trajectory.
3. Vacuum pumps: classification, basic types, range of application; vacuum meters: classification, basic types and range of application.

Recommended Readings:
1. Vacuum Technology, A. Roth, Elsevier
2. Handbook of Vacuum Science and Technology, Dorothy M. Hoffman, John H. Thomas, Bawa Singh, Elsevier Science & Technology Books
3. High Vacuum Technique, J. Yarwood, Chapman and Hall Ltd.

Course Code: PH-AEC-IIC
Course Title: Meteorology
Nature of the Course: AEC
Total Credit assigned: 2

Distribution of Credit: Theory-2

Course Objectives:

1. Make familiar with the Earth's atmosphere as well as the weather and climate systems
2. Provide basic knowledge on meteorological parameters and their measurement techniques
3. Apply the laws of Physics to explain Atmospheric phenomena
4. Get familiar with weather forecasting

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Meteorological fundamentals (L 10, Marks 10)
Basics of weather and climate, composition of the Atmosphere, structure of the atmosphere, Meteorological convention, definition and measurements of Meteorological parameters, solar radiation, heat transfer in the atmosphere, temperature controls, atmospheric stability, hydrostatic equilibrium

Unit II: Dynamics of the Atmosphere (L 10, Marks 10)
Scales of atmospheric motion, factors affecting wind (pressure gradient force, Coriolis force, Friction), types of wind, global circulation, monsoons, westerlies, El Nino-La Nina, Thunderstorms: types and formation mechanisms, weather patterns: cyclone, typhoon, tornados

Unit III: Clouds and Precipitation (L 5, Marks 5)
Formation, classification and microphysics of Clouds, Fog, dew, mist, haze, forms and mechanism of Precipitation, role of clouds in climate system

Unit IV: Weather analysis and forecasting (L 5, Marks 5)
Gathering meteorological data and weather maps, modern numerical weather prediction methods, ranges of forecasts, satellites in weather prediction

Mode of Assessment/ Assessment Tools (%)

In Semester: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test: 10
End Semester: 30
Written Test: 30
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
A student will be able to

1. Demonstrate the various atmospheric phenomena and their evolution
2. Solve problems in the atmospheric sciences and related disciplines
3. Impart expertise in sub-disciplines of atmospheric science or related interdisciplinary areas

4. Develop skills for interpreting and applying atmospheric observation
5. Serve as a meteorologist, climate scientist, take part in policy making

Suggested Readings:

1. Meteorology for Scientists and Engineers, R Stull, Brooks/Cole, Thomson Learning
2. The Atmosphere: An Introduction to Meteorology, Frederick K. Lutgens, Edward J. Tarbuck, Illustrated by Dennis Tasa, PHI Learning Private Limited, Delhi, 11th Edition
3. Basics of Atmospheric Science, A Chandrasekar, PHI Learning Private Limited, Delhi
4. Meteorology Today: An Introduction to Weather, Climate, and the Environment, C. Donald Ahrens , Cengage Learning
5. Environmental Meteorology, B Padmanabha Murty, I.K. International Publishing House Pvt. Ltd., Delhi
6. The Physics of Atmospheres, J Houghton, Cambridge University Press

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GENERIC ELECTIVE COURSES

Course Code: PH-GE-A
Course Title: Basic Quantum Mechanics
Nature of the Course: GE
Total Credit assigned: 4
Distribution of Credit: Theory-4

Course Objectives:

At the completion of this course, a student will be able to

1. Know about the development of modern Physics and the theoretical formulation of quantum mechanics.
2. Know the applications of quantum mechanics in solving physical problems.

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: Origin of Quantum Physics (L 12, Marks 12)

Blackbody radiation, Planck's quantum hypothesis; photo-electric effect; Compton scattering; De Broglie hypothesis, matter waves, Davisson-Germer experiment; wave-particle duality, two-slit experiment with electrons; Heisenberg's uncertainty principle; description of particles by wave packets, group and phase velocities, wave amplitude and wave functions.

Unit II: Formulation of Quantum Mechanics (L 18, Marks 18)

Properties of wave function, probabilistic interpretation; conditions for physical acceptability of wave functions; normalization; position, momentum and energy operators, Hamiltonian operator, expectation values; Schrodinger equation and dynamical evolution of a quantum state, stationary states, time independent Schrodinger equation, energy eigenvalues and eigenfunctions; superposition principle

Unit III: Quantum theory of physical systems (L 20, Marks 20)
One-dimensional infinite square well potential, bound states, energy eigenvalues and eigenfunctions; potential barrier, one-dimensional finite square well potential, Tunneling effect; one-dimensional harmonic oscillator problem; time independent Schrodinger equation in spherical co-ordinates, separation of variable method; theory of Hydrogen atom

Unit IV: Angular momentum (L 10, Marks 10)
Quantum theory of orbital angular momentum; Stern-Gerlach experiment, spin angular momentum

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
The student will be able to
1. Understand the applications of quantum mechanics in other areas of science.
2. Apply quantum theory to physical problems.

Suggested readings:

1. Introduction to Quantum Mechanics, David J. Griffiths, Pearson
2. Quantum Mechanics Concepts and Applications, NouredineZettili, Wiley
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, Wiley.
4. Quantum Mechanics, Leonard I. Schiff, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, PHI

Course Code: PHYSICS-GE-B
Course Title: Foundation of Electronics
Nature of the Course: GE
Total Credit assigned: 4
Distribution of Credit: Theory-4

Course Objectives:
At the completion of this course, a student will be able to
1. Know about the basics of semiconductor PN junction, its various types and its application to different electronic circuits.
2. Understand bipolar junction transistor and its applications as amplifier and oscillators.

3. Familiarize with operational amplifiers, its applications and analysis.
4. Develop knowledge about analog to digital and digital to analog conversion techniques

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

Unit I: Semiconductor Diodes (L 10, Marks 10)
P and N type semiconductors. Energy Level Diagram .Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea).Barrier Formation in PN Junction Diode Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

Unit II: Two-terminal Devices and their Applications (L 6, Marks 6)
(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

Unit III: Bipolar Junction transistors (L 6, Marks 6)
n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Unit IV: Amplifiers (L 20, Marks 20)
Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias.Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.
Two stage RC coupled Amplifier and its frequency response.
Effect of positive and negative feedback on Input impedance, Output impedance, Gain , Stability, Distortion and noise. .

Unit V: Sinusoidal Oscillators (L 5, Marks 5)
Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Unit VI: Operational Amplifiers (Black Box approach) (L 13, Marks 13)
Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.
Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Zero crossing detector, Wein bridge oscillator.

Recommended readings:

1. Electronic Principles, A Malvino, Tata Mc-Graw Hill
2. Electronic devices and circuit theory, Robert Boylested, Prentice Hall.
3. Electronics: Fundamentals and Applications, J.D. Ryder, Prentice Hall.
4. Solid State Electronic Devices,B.G.Streetman&S.K.Banerjee, PHI Learning
5. Electronic Devices & circuits, S.Salivahanan&N.S.Kumar, Tata Mc-Graw Hill
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, Prentice Hall

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learner Outcomes:
This course will enable the students to
1. Learn the foundation knowledge of analog electronic systems.
2. Learn the working and applications of PN junction and bipolar junction transistors (BJT).
3. Learn to analyze circuits containing PN junction and BJT along with the application of BJT as amplifiers and oscillators.
4. Develop basic knowledge of operational amplifier and its applications

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Course Code: PH-GE-C
Course Title: Fundamentals of Material Science
Nature of the Course: GE
Total Credit assigned: 4
Distribution of Credit: Theory-4

Course Objectives:
This course is intended to provide an introduction to
1. The structure of crystalline materials
2. The behavior of conduction electrons in crystalline materials and the formation of energy bands
3. Various types of phenomena like magnetism and super-conductivity
4. Nanomaterials and their interesting properties

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: Crystallography (L 15, Marks 20)
Crystal structure, idea of a lattice, unit cell, Bravais lattices (two and three dimensions), typical crystal structures (SC, FCC, BCC, closed-packed structures), introduction to reciprocal lattice, Wigner-Seitz cell, Miller indices, introduction to reciprocal lattice, Brillouin zone.
X-ray spectra: Characteristic X-ray spectrum, Continuous X-ray spectrum, Moseley's law, X-ray Diffraction, Bragg's equation.

Unit II: Conduction electrons in crystalline solids(L 15, Marks10)
Periodic potential, Bloch theorem, Kronig Penney model, electronic energy bands, E-k diagram, effective mass, metals, insulators and semiconductors.

Unit III: Magnetic Properties of Materials(L 10, Marks8)
Introductory concepts of magnetic materials, para-, dia-, and ferromagnetic materials.

Unit IV: Superconductivity (L 10, Marks10)
Introductory concepts, Meissner effect, type-I & type-II superconductors, London equations, thermodynamics of superconducting transition, idea of BCS theory.

Unit V: Nanostructured materials (L 10, Marks12)
Introduction to nanomaterials, history and scope, interdisciplinary nature, surface to volume ratio, electronic structure, types of nanomaterials, applications of nanomaterials.

Expected learner outcome:
This course will enable the students to
1. Differentiate between different lattice types and explain the concepts of reciprocal lattice and crystal diffraction
2. Predict electrical and thermal properties of solids and explain their origin
3. Explain the concept of energy bands and effect of the same on electrical properties
4. Explain various types of magnetic phenomenon
5. Explain superconductivity
6. Gather knowledge on the underlying principles governing the fascinating behavior of nanomaterials

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Suggested readings:

1. Solid State Physics, N. W. Ashcroft, N. David Mermin, Brooks/Cole
2. Introduction to Solid State Physics C. Kittel, John Wiley & Sons
3. Solid State Physics, A. J. Dekker, Macmillan India Ltd

4. Elementary Solid State Physics, M.A. Omar, Pearson Education
5. Crystallography Applied to Solid State Physics, A.R. Verma and O.N. Srivastava New Age International

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Course Code: PH-GE-D
Course Title: Thermal Physics
Nature of the Course: GE
Total Credits assigned: 04
Distribution of credit: Theory-04

Course Objectives:
At the completion of this course, a student will be able to

1. Develop knowledge on the classical laws of thermodynamics and their application
2. Use the knowledge of thermodynamics in various applications in allied fields like Materials science, Condensed matter Physics, Atmospheric Physics, Solar Physics, etc.
3. Probe questions in varied fields of Physics, chemistry and biology based on principles of Thermal Physics.
4. Use the concept of thermodynamics in real world experiences
5. Develop critical and analytical thinking of the student on thermodynamics and allied disciplines

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: Zeroth and First Law of Thermodynamics (L 15, Marks 15)
Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Unit II: Second Law of Thermodynamics (L 15, Marks 15)
Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit III: Entropy(L 15, Marks 15)
Concept of Entropy, Clausius Theorem. Second Law of Thermodynamics interms of Entropy. Entropy of a perfect gas.Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of AbsoluteZero.

Unit IV: Distribution of Velocities (L 15, Marks 15)
Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, rms and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases, Mean Free Path. Transport Phenomenon

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcomes:

Recommended readings:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Course Code: PH-GE-E
Course Title: Classical Mechanics
Nature of the Course: GE
Total Credit assigned: 4
Distribution of Credit: Theory-4

Course Objectives:
1. Acquaint the learners with the Lagrangian and Hamiltonian formulation of mechanics
2. Enable the learners to understand the idea of normal modes and normal coordinates.
3. Introduce the students to rigid body dynamics

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and

Contact hours:

Unit I: (L 15, Marks 15)
Review of Newtonian mechanics, Mechanics of a system of particles, Constraints of motion and their classification, Generalised co-ordinates, D' Alembert's principle, Lagrange's equations of motion, Hamilton's principle, Symmetries and conservation theorems, Cyclic coordinates.

Unit II: (L 15, Marks 15)
Motion in a central potential, equation of orbits, the Kepler problem, Small Oscillations: Solution of one-dimensional harmonic oscillator problem, Forced oscillations in one dimension, Damped harmonic motion in one dimension-general solution of the problem, coupled oscillation, normal modes and normal coordinates.

Unit III: (L 15, Marks 15)
Hamilton's equations of motion, Legendre's dual transformation, canonical transformations, generating functions, Poisson brackets

Unit IV: (L 15, Marks 15)
Linear transformations, rotations and rotating frames, similarity transformations, linear transformations and eigen value problem, dynamics in rotating reference frames.
Rigid Body Dynamics: Definition of Rigid body, Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcomes:
1. Understand the basic concepts of Lagrangian and Hamiltonian dynamics
2. Understand the idea of normal coordinates and normal modes
3. Understand rigid body dynamics

Suggested Readings:

1. Classical Mechanics, R. D. Gregory, Cambridge University Press
2. Classical Mechanics, H.Goldstein,Addison Wesley
3. Classical Mechanics, N.C. Rana& P.S. Joag,Tata McGraw Hill
4. Classical Mechanics of Particles and Rigid Bodies, Kiran C Gupta,Wiley Eastern Limited
5. Introduction to Classical Mechanics, R.G. Takwale& P.S. Puranic, Tata McGraw Hill

Course Code: PH-GE-F
Course Title: Meteorology
Nature of the Course: GE
Total Credit assigned: 4
Distribution of Credit: Theory-4

Course Objectives:

1. Familiarize with the structure and composition of the atmosphere of Earth and other planets
2. Provide basic knowledge on the weather, climate and other aspects of atmosphere
3. Provide knowledge on meteorological parameters and their measurement techniques
4. Familiarize with weather forecasting

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: Physical Meteorology (L 22, Marks 22)

Introduction to Planetary Atmosphere, structure and composition of the Atmosphere and other planets, Atmospheric thermodynamics- heat transfer in the atmosphere, warming and cooling of the Earth and its atmosphere, temperature controls, atmospheric stability, overview of meteorological parameters-wind speed and direction, temperature, humidity, pressure, solar radiation, rainfall, meteorological instruments, meteorological convention, graphical representation of the meteorological parameters, world climate systems
Clouds development and precipitation: Formation mechanism, classification and microphysics of Clouds, Fog, dew, mist, haze, forms and mechanism of Precipitation, role of clouds in climate system

Unit II: Dynamic Meteorology (L 20, Marks 20)
Atmospheric circulation-scales of atmospheric motion, vorticity, boundary layer and turbulence, wind types-local and global, factors affecting wind- pressure gradient force, Coriolis force, Friction, global circulation of the atmosphere, monsoons, atmospheric waves-gravity waves, Rossby waves, westerlies, Ocean- Atmosphere interaction-El Nino-La Nina,
Thunderstorms and tornados: types and formation mechanism, weather patterns: cyclone, typhoon, tornados

Unit III: Synoptic Meteorology (L 10, Marks 10)
Weather observations, weather maps, weather prediction tools and methods, numerical weather prediction, time range of forecasts, satellites and radars in weather prediction, weather forecasting using surface chirts

Unit IV: Environmental Meteorology (L 8, Marks 8)

Effect of meteorology on air pollution and climate-dispersion of air pollutants, air quality, climate variability and climate change, concept of chemical weather, urban impacts on meteorological parameters

Mode of Assessment/ Assessment Tools (%)

In Semester: 40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20
Written Test: 20
End Semester: 60
Written Test: 60
(Equal weightage to be assigned to each credit)

Expected Learning Outcome:
A learner will be able to
1. Demonstrate the various atmospheric phenomena and their evolution
2. Use meteorological parameters to explain observations in Atmospheric Physics, Life Sciences, Environmental Science etc.
3. Apply the laws of Physics to explain Atmospheric phenomena
4. Opt for interdisciplinary research

Suggested Readings:

1. Meteorology for Scientists and Engineers, R Stull, Brooks/Cole, Thomson Learning
2. The Atmosphere: An Introduction to Meteorology, Frederick K. Lutgens, Edward J. Tarbuck, Illustrated by Dennis Tasa, PHI Learning Private Limited, Delhi
3. Basics of Atmospheric Science, AChandrasekar, PHI Learning Private Limited, Delhi
4. Meteorology Today: An Introduction to Weather, Climate, and the Environment, C. Donald Ahrens, Cengage Learning
5. Environmental Meteorology, B PadmanabhaMurty, I.K. International Publishing House Pvt. Ltd., Delhi
6. The Physics of Atmospheres, J Houghton, Cambridge University Press
7. Essentials of Meteorology, An invitation to the Atmosphere, C D Ahrens and R Henson, Cengage Learning

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Course Code: PH-GE-G
Course Title: Elements of Modern Physics
Nature of the Course: GE
Total Credits Assigned: 04
Distribution of credits: Theory-04

Course Objectives:

At the completion of this course, a student will be able to

1. Understand the theoretical basis for the understanding of quantum Physics as the basis for dealing with microscopic phenomena.
2. Apply concepts of 20^{th} Century Modern Physics to deduce the structure of atoms.
3. Explain the wave-particle duality of the photon.
4. Analyze the structure of matter at its most fundamental.
5. Develop insight into the key principles and applications of Nuclear Physics
6. Learn about different types of fundamental particles along with various elementary particles
7. Understand the basic principle of Laser

Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:

Unit I: (L 15, Marks 15)

Quantum theory of Light, Blackbody Radiation; Photo-electric effect, Compton scattering. De Broglie hypothesis and matter waves, Wave-particle duality, Heisenberg uncertainty principle. Schrodinger equation for non-relativistic particles; physical interpretation of a wave function, probabilities and normalization of wave function; Particle in a box problem in one dimension - energy eigen values and eigen functions.

Unit II: (L 15, Marks 15)

Quantum numbers, Bohr's atomic model, spectral terms arising from L-S coupling and j-j coupling, selection rules and intensity rules, Doublet spectra of Na-atom.

X-ray spectra: Characteristic X-ray spectrum, Continuous X-ray spectrum, Moseley's law, X-ray Diffraction, Bragg's equation.

Unit III: (L 20, Marks 20)

Size and structure of atomic nucleus; Absence of electron in the nucleus as a consequence of the uncertainty principle, Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy, nuclear shell structure and magic numbers.

Radioactivity; Law of radioactive decay; Mean life and half-life; Qualitative ideas on Alpha decay; Beta decay; Gamma ray emission. Nuclear reactions, Fission and fusion, Nuclear reactor; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Elementary particles: classification, fundamental interactions.

Unit IV: (L 10, Marks 10)

Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	20
Written Test:	20
End Semester: 60	
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

This course will enable the students to

1. Gather knowledge about various concepts of Modern Physics such as quantum physics, atomic, nuclear physics and particle physics, Laser etc.
2. Successfully apply the same knowledge in solving problems in the field of Modern Physics.

Recommended Readings:

1. Concepts of Modern Physics, Arthur Beiser, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, Tata McGraw Hill
   Introduction to Quantum Mechanics, David J. Griffith, Pearson Education.
3. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, Cengage Learning.
4. Modern Physics, G.Kaur and G.R. Pickrell, McGraw Hill
5. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, Macmillan
6. Lasers and Nonlinear Optics, B. B. Laud, New Age International