NOIDA INTERNATIONAL UNIVERSITY

DEPARTMENT OF PHYSICS

SYLLABUS OF COURSES TO BE OFFERED

Core Courses, Elective Courses & Ability Enhancement Courses

POSTGRADUATE PROGRAMME

Choice Based Credit System (CBCS)

(Academic Year 2020-21)

Preamble

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades.

The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So, it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

M. Sc. Programme Details

Programme Objectives (POs)

The objectives of the M.Sc. Physics programme are manifold and start with imparting students with an in-depth knowledge and understanding through the core courses which form the basis of Physics namely, Classical Mechanics, Quantum Mechanics, Mathematical Physics, Statistical Physics, Electromagnetic Theory, Solid State Physics, Electronics, Nuclear and Particle Physics along with Atomic and Molecular Physics. Creative thinking and problem-solving capabilities are also aimed to be encouraged through tutorials. The elective and open elective courses are designed for more specialized and/or interdisciplinary content to equip students with a broader knowledge base. The core and elective labs are designed to develop an appreciation for the fundamental concepts and working of devices used in everyday life employing scientific methods/tools of physics. Computational physics course is aimed to equip the students to use computers as a tool for scientific investigations/understanding. The dissertation(s) in both theory and experimental stream are expected to give a flavor of how research leads to new findings. In addition, the M.Sc. course is to lay a solid foundation for a doctorate in Physics/allied subjects later.

Programme Specific Outcomes (PSOs)

1) Understanding the basic concepts of physics particularly concepts in classical mechanics, quantum mechanics, statistical mechanics and electricity and magnetism to appreciate how diverse phenomena observed in nature follow from a small set of fundamental laws through logical and mathematical reasoning.

2) Learn to carry out experiments in basic as well as certain advanced areas of physics such as nuclear physics, condensed matter physics, nanoscience, lasers and electronics.

3) Understand the basic concepts of certain sub fields such as nuclear and high energy physics, atomic and molecular physics, solid state physics, and plasma physics, and astrophysics, general theory of relativity, nonlinear dynamics and complex system.

4) Gain hands on experience to work in applied fields.

5) Gain a through grounding in the subject to be able to teach it at college as well as school lever.

6) Viewing physics as a training ground for the mind developing a critical attitude and the faculty of logical reasoning that can be applied to diverse fields.

Course Structure

Details of Courses under M.Sc. Physics

Courses	Credits
I. Core Course (12 papers of 4 Credits Each)	**12x4 = 48**
II. Discipline Specific Elective Course (DSE) (Minimum 5 papers of 4 Credits Each)	**5x4 = 20**
III. Ability Enhancement Course (AEC) (Minimum 2 papers of 2 Credits Each)	**2X2 =04**
IV. Generic Elective Course (GE) (2 papers of 4 Credits Each)	**2x4 = 08**
Total Credit (Minimum)	**80**

***Dissertation/Project (Credits 2) as an additional AEC in Semester IV**

SCHEME FOR CHOICE BASED CREDIT SYSTEM
M. SC. IN PHYSICS

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

* Student can opt for Dissertation/Project (Credits 2) as an additional AEC in Semester IV.

Semester	Course Structure	Course Name	Credits
I	Core course-I	Mathematical Physics	4
	Core Course-II	Quantum Mechanics	4
	Core course-III	General Lab-I	4
	Discipline Specific Elective –I	DSE I	4
	Ability Enhancement Course – I	AEC I	2
II	Core course-IV	Classical Mechanics	4
	Core course-V	Condensed Matter Physics	4
	Core course-VI	General Lab-II	4
	Discipline Specific Elective –II	DSE II	4
	Generic Elective – I	GE I	4
III	Core course-VII	Electronics	4
	Core Course-VIII	Electrodynamics	4
	Core course-IX	Computational Methods	4
	Discipline Specific Elective –III	DSE III	4
	Generic Elective – II	GE II	4
	Ability Enhancement Course – II	AEC II	2
IV	Core course-X	Nuclear Physics	4
	Core course-XI	Statistical Mechanics	4
	Core course-XII	Atomic & Molecular Physics	4
	Discipline Specific Elective –IV	DSE IV	4
	Discipline Specific Elective –V Additional AEC	DSE V Dissertation/Project	4 2

***Additional AEC: Dissertation/Project (Credits 2) in semester IV**.

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

I. Mathematical Physics
II. Quantum Mechanics III.
III. General Lab I
IV. Classical Mechanics
V. Condensed Matter Physics
VI. General Lab II
VII. Electronics
VIII. Electrodynamics
IX. Computational Methods
X. Nuclear Physics
XI. Statistical Mechanics
XII. Atomic & Molecular Physics

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

DSE I (Minimum one):

A. Theory of Relativity
B. Atmospheric Physics

DSE II (Minimum one):

A. Plasma Physics
B. Advanced Quantum Mechanics

DSE III: (Minimum one)

A. High Energy Physics I
B. Condensed Matter Physics I
C. Communication Electronics
D. Advanced Mathematical Physics
E. Laser Spectroscopy I

DSE IV: (Minimum one)

A. High Energy Physics II
B. Condensed Matter Physics II
C. Digital and Optical Electronics
D. Space Physics
E. Laser Spectroscopy II

DSE V: (Minimum one)

A. Condensed Matter Physics Lab
B. Electronics Lab
C. Space Physics Lab
D. Laser Spectroscopy Lab

Generic Elective Papers (GE): (Credit: 04 each)
(Minimum 2 papers to be selected)- GE I and II

GE I: (Minimum one)

A. Basic Quantum Mechanics
B. Foundation of Electronics
C. Fundamentals of Material Science

GE II: (Minimum one)

A. Thermal Physics
B. Classical Mechanics
C. Meteorology
D. Elements of Modern Physics

Ability Enhancement Course Papers (AEC): (Credit: 02 each)
(Minimum 2 papers to be selected)- AEC I and II

AEC I: (Minimum one)

A. Experimental Techniques
B. Observational Astronomy

AEC II: (Minimum one)

A. Nano Structured Materials
B. Vacuum Technique
C. Meteorological Fundamentals

Additional AEC II: (2 credits)

D. Dissertation/Project

Abbreviations:

L: Lecture, T: Tutorial

NOIDA INTERNATIONAL UNIVERSITY
SCHOOL OF SCIENCES
Study & Evaluation Scheme for M.Sc. Physics
Effective from the Session: 2020-21

SEMESTER-I

S. No	Course Name	Course Code	Course Type	Period			Evaluation Scheme				Subjec t Total	Credit
				L	T	P	CA	TA	Total	External Exam		
1	Mathematical Physics	PH-C-I	Core	3	1	0	20	20	40	60	100	4
2	Quantum Mechanics	PH-C-II	Core	4	0	0	20	20	40	60	100	4
3	General Lab-I	PH-C-III	Core	0	0	4	25	25	50	50	100	4
4	Theory of Relativity Atmospheric Physics (Minimum one to be Opted)	PH-DSE-IA PH-DSE-IB	DSE	4	0	0	20	20	40	60	100	4
5	Experimental Techniques Observational Astronomy (Minimum one to be Opted)	PH-AEC-IA PH-AEC-IB	AEC	2	0	0	20	20	40	60	100	2
Total											**500**	**18**

SEMESTER-II

S. No	Course Name	Course Code	Course Type	Period			Evaluation Scheme				Subject Total	Credit
				L	T	P	CA	TA	Total	External Exam		
1	Classical Mechanics	PH-C-IV	Core	4	0	0	20	20	40	60	100	4
2	Condensed Matter Physics	PH-C-V	Core	4	0	0	20	20	40	60	100	4
3	General Lab-II	PH-C-VI	Core	0	0	4	25	25	50	50	100	4
4	Plasma Physics Advanced Quantum Mechanics (Minimum one to be Opted)	PH-DSE-IIA PH-DSE-IIB	DSE	3 4	1 0	0	20	20	40	60	100	4
5	Basic Quantum Mechanics Foundation of Electronics Fundamentals of Material Science (Minimum one to be Opted)	PH-GE-IA PH-GE-IB PH-GE-IC	GE	4	0	0	20	20	40	60	100	4
Total											**500**	**20**

NOIDA INTERNATIONAL UNIVERSITY

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Study & Evaluation Scheme for M.Sc. Physics

Effective from the Session: 2020-21

SEMESTER-III

S. No	Course Name	Course Code	Course Type	Period			Evaluation Scheme				Subject Total	Credit
										External Exam		
				L	T	P	CA	TA	Total			
1	Electronics	PH-C-VII	Core	3	1	0	20	20	40	60	100	4
2	Electrodynamics	PH-C-VIII	Core	4	0	0	20	20	40	60	100	4
3	Computational Methods	PH-C-IX	Core	3	0	1	20	20	40	60	100	4
4	High Energy Physics I Condensed Matter Physics I Communication Electronics Advanced Mathematical Physics Laser Spectroscopy I (Minimum one to be Opted)	PH-DSE-IIIA PH-DSE-IIIB PH-DSE-IIIC PH-DSE-IIID PH-DSE-IIIE	DSE	4 4 4 3 3	0 0 0 1 1	0	20	20	40	60	100	4
5	Thermal Physics Classical Mechanics Meteorology Elements of Modern Physics (Minimum one to be Opted)	PH-GE-IIA PH-GE-IIB PH-GE-IIC PH-GE-IID	GE	4	0	0	20	20	40	60	100	4
6	Nano Structured Materials Vacuum Technique Meteorological Fundamentals (Minimum one to be Opted)	PH-AEC-IIA PH-AEC-IIB PH-AEC-IIC	AEC	2	0	0	20	20	40	60	100	2
Total											**600**	**22**

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Study & Evaluation Scheme for M.Sc. Physics
Effective from the Session: 2020-21

SEMESTER-IV

S. No	Course Name	Course Code	Course Type	Period			Evaluation Scheme				Subject Total	Credit
				L	T	P	CA	TA	Total	External Exam		
1	Nuclear Physics	PH-C-X	Core	4	0	0	20	20	40	60	100	4
2	Statistical Mechanics	PH-C-XI	Core	3	1	0	20	20	40	60	100	4
3	Atomic & Molecular Physics	PH-C-XII	Core	4	0	0	20	20	40	60	100	4
4	High Energy Physics II Condensed Matter Physics II Digital and Optical Electronics Space Physics Laser Spectroscopy II (Minimum one to be Opted)	PH-DSE-IVA PH-DSE-IVB PH-DSE-IVC PH-DSE-IVD PH-DSE-IVE	DSE	4 4 4 4 3	0 0 0 0 1	0	20	20	40	60	100	4
5	Condensed Matter Physics Lab Electronics Lab Space Physics Lab Laser Spectroscopy Lab (Minimum one to be Opted)	PH-DSE-VA PH-DSE-VB PH-DSE-VC PH-DSE-VD	DSE	0	0	4	25	25	50	50	100	4
6	Dissertation/ Project (Additional)	PH-AEC-IID	AEC	0	0	2			50	50	100	2
	Total										**600**	**22**

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

Course Objectives:
At the completion of this course, a student will be able to
(1) Write a. problem in higher level Physics in the language in Mathematics.
(2) Identify a range of diverse mathematical techniques to formulate and solve a problem in higher level physics.
(3) Analyze various mathematical concepts and methods.
(4) Apply the knowledge and understanding of these mathematical techniques to gain insight into a number of branches of physics like Quantum Mechanics, Electromagnetic Theory, Condense Matter Physics, Atomic and Molecular Physics, Nuclear Physics, Particle and High Energy Physics, Physics of Gravity etc.

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

Unit I: Linear Vector Spaces (L 15, T 8, Marks 23)
Review of vector analysis; definition of vector spaces; finite dimensional vector spaces: linear independence, basis and dimensionality, inner product of vectors and norm of vector, Schmidt's orthogonalization method, Schwarz's and Bessel's inequalities; matrices: orthogonal, Hermitian, unitary and normal matrices; linear operators: matrix representation of linear operators; linear transformation: similarity transformation, orthogonal and unitary transformations; eigenvectors and eigenvalues, diagonalization of matrices (or operators); infinite dimensional vector space: Hilbert space, Fock space.

Unit II: Partial Differential equations (L 10, T 5, Marks 15)
Partial differential equations and boundary conditions: coordinate systems, cartesian, cylindrical, spherical polar, boundary value problems on Laplace equation, Poisson equation and diffusion equation; Green's function method of solving partial differential equations.

Unit III: Group Theory (L 7, T 3, Marks 10)
Groups, subgroups, classes and characters, cosets, factor group, normal subgroup, point symmetry group, direct and semidirect product of groups, homomorphism and isomorphism, representation of a group, Lie groups, generators of continuous group, rotation groups, unitary groups, special unitary groups.

Unit IV: Tensor Analysis (L 8, T 4, Marks 12)
Basics of tensor algebra, 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

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 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. 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: Quantum Mechanics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objectives:
(a) Acquaint the learners with 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 20, Marks 20)
Overview of wave mechanics, Schrödinger equation, application to some important physical problems: particle in a box, simple harmonic oscillator, hydrogen atom, the Stern Gerlach Experiment, Kets, Bras and Operators, Base Kets and Matrix Representations, Measurements, Observables and Uncertainty Relations, Change of basis, Position, momentum and translation Wave functions in Position and Momentum Space.

Unit II: Quantum Dynamics (L 30, Marks 30)
Time evolution and the Schrödinger equation, the Schrödinger versus the Heisenberg picture, time evolution of the simple harmonic oscillator**,** Time independent perturbation theory: Non degenerate case, Time independent perturbation theory: Degenerate case, Hydrogen like atoms: Fine structure and Zeeman Effect, Variational methods, Time dependent potentials: the Interaction picture, Time dependent perturbation theory, Applications to Interactions with Classical Radiation field, WKB Approximation

Unit III: Symmetry in Quantum Mechanics (L 10, Marks 10)
Symmetries, Conservation laws and Degeneracy, Space and Time displacements, Rotation, Angular Momentum and Unitary groups, commutation relations, Density operators and Pure versus Mixed Ensembles, Eigenvalues and Eigenstates of Angular Momentum, Addition of Angular momentum, Clebcsh Gordon Coefficients

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

Expected Learning Outcome:

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-III
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 systems for 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 Effect.
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 draw the characteristics of a Zener diode and find the breakdown voltage & to study the Zener diode as a voltage regulator under (a) input variation & (b) load variation.
11. To determine the velocity of sound using CRO.
12. To determine the plateau and optimal operating voltage of a Geiger-Müller counter.
13. To measure the half-life of meta-stable Barium-137.

Mode of Assessment/ Assessment Tools (%)

In Semester: 50	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	25
Viva Voce:	25
End Semester: 50	
Laboratory experiments:	50
(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-IV
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 integrable, 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

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-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. Familiarize with 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.

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, Type-I & Type-II superconductors, London equations, 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

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 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 realise the Network theorems. (Thevenins, Norton and superposition)
2. To study a stable, monostable and bistable multivibrator and to obtain the value of the unknown capacitors.
3. To design and study D/A converter using R-2R Ladder network.
4. (a)To design and study OPAMP as an inverting and non inverting amplifier.
   (b)To design and study OPAMP as a differentiator and integrator.
5. To draw the frequency response curve of an RC coupled amplifier with and without negative feedback and compare the bandwidth.
6. To design a transistor amplifier for a gain of 7 using Voltage divider biasing method.
7. To design a RC Oscillator and Wien Bridge Oscillator for generating Sinusoidal oscillation of frequency 200 Hz and 3 KHz.
8. To design square wave generator for a frequency of 500Hz and 2 KHz.
9. To design and construct basic flip-flops R-S, J-K, J-K Master slave flip-flops using gates and verify their truth tables.
10. To realize One- & Two-Bit Comparator and study of 7485 magnitude comparator.
11. To realize and study of 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)
12. To design and test 3-bit binary asynchronous counter using flip-flop IC 7476 for thegiven sequence.
13. To study the characteristic curves of (i) FET (ii) MOSFET

Mode of Assessment/ Assessment Tools (%)

In Semester: 50
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 25
Viva Voce: 25
End Semester: 50
Laboratory experiments: 50
(One experiment from the list of experiments to be performed)

Expected Learning Outcome:
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

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Course Code: PH-C-VII
Course Title: Electronics
Nature of the Course: Core
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: (L 20, Marks20)

Introduction to voltage and current source and measuring devices, Concept of source loading, implication and mitigation of source loading, BJT fundamentals and biasing techniques, β independence, Early effect, load line, amplifying action, Emitter follower, impedance matching application, ac models: T and π, analysis and design of small signal amplifier, 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, active load, introduction to CMOS and FINFET technology.

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, operational amplifiers, CMRR, Slew rate etc open loop configuration-comparators, inverting and non-inverting amplifiers, OPAMP with feedback, negative, voltage-series feedback, voltage follower, applications of OPAMS-summing, integrator, differentiator, logarithmic amplifier, zero crossing detector etc to analog computation.

Unit III: Digital Electronics (L 15, Marks 15)

Review of Sequential circuits: flip flops: RS, JK, D-,T-, M/S JK, Clock: level and edge triggered, preset and clear signals, race around and toggling condition and mitigations, counters: ring, synchronous, asynchronous, module of counter: decade counter, registers: shift register: parallel and serial input/output, multiplexer, demultiplexer, encoder, decoder, ADC: SA method, counter etc DAC: weighted resistor, R-2R ladder etc, RAM and ROM as memory element.

Unit IV: Introduction to Microprocessor and Microcontroller (L 10, Marks 10)

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.

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

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. Integrated Electronics: Analog and Digital Circuit Systems J. Millman and C. Halkias McGraw Hill
4. Digital Principles and Applications D.P. Leach and A.P. Malvino Tata McGraw Hill
5. Semiconductor Materials and Devices M.S. Tyagi John Wiley and Sons
6. Physics of Semiconductor Devices S.M. Sze Wiley Eastern Ltd.
7. The Art of Electronics P. Horowitz and W. Hill Cambridge University Press
8. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Course Code: PH-C-VIII
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)
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
Boundary value problems in spherical coordinate

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:
After completion of the course, students will be able to:

1. Describe the 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

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Course Code: PH-C-IX
Course Title: Computational Methods
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-03, Lab-1

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

1. Get hands on training in problem solving using FORTRAN language in LINUX operating system.
2. 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 3, Practical 2, Marks 5)**
Windows and Unix user commands

Unit II: **(L 15, Practical 5, Marks 20)**
FORTRAN programming, flow chart, 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.

Unit III: **(L 7, Practical 3, Marks 10)**
Significant digits, Approximations and errors in computing: introduction, data errors, round off error, truncation error, modeling error, significant digits, absolute and relative error, general formula of errors, error estimation.

Unit IV: **(L 18, Practical 7, Marks 25)**
Elementary probability theory, random variables, binomial, Poisson and Normal distributions, central limit theorem, chi-square test.
Determination of root of functions, roots of nonlinear equations: Bisection method, method of false position, Newton-Raphson method, numerical integration by trapezoidal and Simpson's rule, numerical differentiation: Finite difference methods, central difference formula, extrapolation.
Solution of first order ordinary differential equation: Runge-Kutta method.
Linear and non-linear curve fitting: Lagrange interpolation polynomial, Newton-Gregory method.

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. Apply their knowledge on computer programming and numerical analysis in solving real physical problems.
2. 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-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

1. Have a basic knowledge of the nuclear force and its properties
2. Be able to visualize the nature of interaction of nucleons inside deuteron nucleus as well as in general nucleon-nucleon scattering
3. Be acquire knowledge about different theoretical models regarding nucleus as well as to apply those in determining nuclear properties
4. Grasp knowledge about nuclear reactions and their various mechanisms along with a wide understanding of the decay process
5. Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail
6. 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 10, Marks 10)

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

Unit II: (L 18, Marks 18)

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, limitations of the shell model.

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, nuclear fission, neutrino hypothesis and general features of β-ray spectrum, Fermi's theory of β-decay, Curie plot, selection rules.

Unit IV: (L 12, 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 5, Marks 5)

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

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. 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

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 solved 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

Course Code: PH-C-XII
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 Spectroscopy (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 Spectroscopy (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: Laser Spectroscopy (L 12, Marks 12)

Fundamentals of Lasers-properties, basic elements, threshold condition, rate equation, population inversion, Laser resonator and modes, types of laser- solid state laser, gas laser, semi-conductor laser, applications of laser spectroscopy, Laser Cooling, Ammonia Masers-two level and three level

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 Molecules, 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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DISCIPLINE SPECIFIC ELECTIVE COURSES

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

Course Objectives:
The objective of this course is to
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 Outcome:

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

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-IB
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 atmospheric thermodynamics.
3. Introduce atmospheric aerosols and analyse its impact on the global climate.

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

Unit I: Introduction to Earth's Atmosphere (L 15, Marks 15)
State of the earth's atmosphere: main constituents of dry air, CO2, Ozone, water vapor, aerosols; vertical thermal structure of the atmosphere: Troposphere, stratosphere, mesosphere, thermosphere and exosphere; Environmental lapse rate, hydrostatic equilibrium, hydrostatic equation

Unit II: Atmospheric Thermodynamics (L 15, Marks 15)
Gas laws, ideal gas law, Dalton's law, first law of thermodynamics, equivalence between heat and work, thermal capabilities, isothermal, isochoric, isobaric transformation, adiabatic transformation, Poisson relation, thermodynamic properties of water, latent heat, Clausius-Clapeyron's relation, Approximation and consequences of Clausius-Clapeyron relation, moist air, mean molecular weight of dry and moist air

Unit III: Chemistry of the Troposphere and Stratosphere (L 15, Marks 15)
Ozone photochemistry, Chapman cycle, limitations of Chapman model, O3 photolysis, altitude, latitude, diurnal and seasonal variation of ozone, heterogeneous reaction, ozone distribution, HOx, NOx, CLOx cycles, Tropospheric ozone

Unit IV: Atmospheric Aerosols (L 15, Marks 15)
Aerosols: optical and physical properties, chemical composition, size distribution, vertical distribution
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

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. Acquainted with the different layers of the atmosphere and the related physical phenomena.
2. Develop simple models of the atmosphere.
3. Understand the optical and microphysical properties of aerosol.
4. Understand the atmospheric chemistry of trace gases.

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 Modelling, M Z Jacobson, Cambridge University Press
5. An Introduction to Atmospheric Radiation, K N Liou, Academic Press

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Course Code: PH-DSE-IIA
Course Title: Plasma Physics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory-03, Tutorial-01

Course Objectives:
The objective of the course is to

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 8, T 4, Marks 12)
Definition of plasma, Concept of temperature, Debye shielding, plasma parameters, criterion for plasma, Classification of Plasma, Applications of Plasma Physics.

Unit II: (L 8, T 6, Marks 14)
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 10, T 7, Marks 17)
Plasma as fluids: Introduction, relation of plasma physics to ordinary electromagnetics, Fluid equation of motion, Fluid drifts perpendicular and parallel to B, Plasma approximation. Plasma confinement

Unit IV: (L 10, T 7, Marks 17)
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

Suggested 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.

Course Code: PH-DSE-IIB
Course Title: Advanced Quantum Mechanics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of Credits: Theory - 4

Course Objectives:
The objective of the course is to

1. Acquaint the learners with the approximation methods in Quantum Mechanics.
2. Introduce the quantum mechanical treatment of scattering
3. 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: Scattering Theory (L 10, Marks 10)
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 II: Path Integral Approach (L 25, Marks 25)
Quantum mechanical law of motion: Classical Action, quantum mechanical amplitude, the sum over paths, examples: the free particle, diffraction through a slit. Path integral as a functional, evaluation of path integrals, perturbation method in quantum mechanics, transition elements.

Unit III: Relativistic Quantum Mechanics (L 25, Marks 25)
Brief overview of Special Theory of Relativity, Four vectors, Klein Gordon Equation, Dirac Equation, Spin angular momentum, Dirac matrices, covariant form of Dirac equation, Zitterbewegung, 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:
After completion of the course the student will be able to

1. Understand the idea of different approximation techniques in quantum mechanics
2. Understand the quantum mechanical approach to scattering
3. 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-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. Express physical quantities in natural units.
2. Explain the physics of relativistic wave equations.
3. Use the formulation of quantum field theory in a number of fields.
4. Apply the concepts of quantum field theory to quantum electrodynamics.

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

Unit I: Relativistic Wave Equations (L 10, Marks 10)

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.

Unit II: 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 eigenvalues, 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 III: Quantum Electrodynamics (L 25, Marks 25)

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.

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. After the completion of this course, it is expected that this course will
2. Enable a student to acquire the basics of quantum field theory and realize its importance.
3. Enable a student to apply the framework of field theory to quantum electrodynamics.
4. Prepare a student for advanced topics in field theory and particle physics.

5. 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 Press.

Course Code: PH-DSE-IIIB
Course Title: Condensed Matter Physics 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. Gather a broader knowledge of Electronic Properties of Solids.
2. Understand the chronology in the Development of the Electron theory in Metals.
3. Understand comparatively the Polarisation and Magnetisation behavior in a solid.

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, Wiedmann Franz law, nearly free electron model, tight 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.
dipole theory of ferroelectricity, thermodynamics of ferroelectricity, first and second order transitions, anti-ferroelectricity.

Unit III: Magnetic Properties of a System (L 14, Marks 14)
Hartree and Hartree-Fock approximation, Hartree exchange and Heisenberg Hamiltonian, the ground state and excited states in Hartree-Fock approximation, Heisenberg ferromagnet and spin waves.

Unit IV: Superconductivity (L 14, Marks 14)
Isotope effect, electron-phonon interaction, BCS theory, flux quantization in a superconducting ring, superconducting tunneling, AC and DC Josephson effects, Ginsberg – Landau theory, 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

Course Code: PH-DSE-IIIC
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: Modulation Techniques (L 8, Marks 8)
Sampling theorem, quantization, pulse code modulation (PCM), Dynamic range, companding, Delta modulation, granular noise, slope overloading, adaptive delta modulation, differential PCM, Noise in communication system-representation of noise and signal-to-noise ratio at output, white noise.

Unit II: Digital modulation technique (L 10, Marks 10)
Concept of bit rate, baud, bandwidth, ASK, FSK, BPSK, QPSK, 8PSK, 16PSK, QAM, probability of error and bit error, data communication codes, bar codes, error detection, error correction.

Unit III: Spread spectrum and Multiple accessing (L 6, Marks 6)
Frequency hopping, DSSS.CDMA, TDM, FDM, WDM

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, antenna parameters, dipole arrays, folded dipole, log-periodic antenna, loop antenna, UHF and microwave antennas, microstrip antenna, scattering parameters and their measurements, vector network analyser

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.

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-IIID
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, trans critical 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; sub manifolds; 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-IIIE
Course Title: Laser Spectroscopy I
Nature of the Course: DSE
Total credits assigned: Theory-04
Distribution of credits: (L 3, T 1)

Course Objectives:

1. Familiarize with various branches of spectroscopy
2. Equip with the knowledge on spectroscopic techniques and instrumentation
3. Learn to use spectroscopic techniques to apply in wide range of areas
4. Learn theoretical background of laser, its importance as spectroscopic light source and different types

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

Unit I: Matter-radiation interaction (L 15, T 5 Marks 20)
Overview of different Spectroscopic techniques, absorption and emission of radiation, Einstein's coefficients, Coherent properties of radiation fields, Transition probabilities- weak and strong field approximation, Cavity radiation-counting the number of cavity modes, Plank's law for cavity modes, basic photometric quantities, widths and profiles of spectral lines, overview of spectroscopic instrumentations-detection of light, interferometers, photo emissive detectors

Unit II: Lasers as spectroscopic light source (L 20, T 5 Marks 25)
Basic elements of lasers, development and growth of a laser beam, saturation intensity, growth factor , properties of lasers- coherency, directionality, monochromaticity light amplification, threshold condition for laser oscillation, laser amplifiers, spectral characteristics, laser rate equations- three and four level systems, laser resonators-longitudinal and transverse cavity modes, Types of lasers with examples: solid state, gas laser, Dye laser, and semiconductor lasers, liquid and chemical lasers, free-electron lasers, excimer lasers, X-ray laser, Advantages of Lasers in spectroscopy

Unit III: Time resolved laser spectroscopy (L 10, Marks 10)
Generation of short laser pulses-Q-switched lasers, mode locking of lasers, laser amplifiers, femtosecond pulses, measurement of ultrashot pulses, life time measurements with lasers, pump and probe techniques, gamma ray lasers

Unit IV: Applications of laser spectroscopy (L 10, T 5 Marks 15)
Applications of lasers- Physics, Chemistry, Environmental Research, Material Science, Biology, Medical Science, communication, Atmospheric optics, industry, Holography

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 will be able to:

1. Understand and explain fundamental concepts in laser spectroscopy
2. Compare the function and properties of different types of lasers
3. Use laser spectroscopic instruments in practice in physics and allied disciplines
4. Demonstrate the production mechanism of conventional as well as ultrafast lasers

Suggested readings:

1. Molecular Spectra and Molecular Structure G. Herzberg McGraw Hill
2. Molecular Structure and Spectroscopy, G Aruldhas, PHI Learning Pvt Ltd, Delhi
3. Fundamental of Molecular Spectroscopy, Banwell and McCash,Tata McGraw Hill
4. Laser Spectroscopy, W. Demtrider, Springer
5. Laser Fundamentals, W T Silfvast, Cambridge University press
6. Lasers and Non-linear Optics, B B Laud, New age international limited, publishers
7. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut

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Course Code: PH-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. Classify the elementary particles and their interactions.
2. Explain the physics of fundamental particles and their interactions.
3. Analyze the formulation of group theory.
4. Apply group theory to quark model and different interactions.

Unit wise distribution of course contents with unit wise distribution of weightage 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 20, Marks 20)
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 and charm quark, heavy quarks beyond charm, quark color, hadron wave functions, quark model predictions: magnetic moment, hadron masses.

Unit III: Particle Interactions (L 20, Marks 20)
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 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 andLeptons,FranciseHalzen 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-IVB
Course Title: Condensed Matter Physics II
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory – 04

Course Objective:
The objective of the course is to
1. Provide basic knowledge on Lattice vibration and some properties of solid related to lattice vibration.
2. 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. 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 25, Marks 25)
Intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Fermi level, Hall effect.
Rectifying properties of barriers, Schottky theory of M.S contact, surface states, p-n junction rectifiers, transistors and solar cells
Photovoltaic device principles, equivalent circuit of solar cell, temperature effects, solar cell materials, devices and efficiencies.
Optical and high frequency effects in semiconductors, optical constants, free carrier absorption, fundamental absorption, direct and indirect transitions, lattice absorption.

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 the course the student will be able to

1. Use the knowledge in fabrication of different thin film semiconductor devices.
2. Pursue 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 Hill
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-IVC
Course Title: Digital and Optical Electronics
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Theory-04

Course Objectives:

Objective of the course is to

1. Introduce students to microcontroller and programming for building digital systems.
2. Introduce students to digital signal and signal processing principles
3. Introduce students to optical electronic systems
4. Provide students with fundamental principles of optical devices
5. Introduce students to optical communication systems

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

Unit I: Digital system using Microcontroller/Microprocessor (L 10, Marks 12)

8085 programming, introduction to specification and architecture of microcontroller, 8051 family, instruction set, addressing mode, programming, time delay generation, look up table implementation etc.

Unit II: Introduction to digital signal processing (L 15, Marks 12)

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 III: Optical electronics: Review of semiconductor and optics (L 10, Marks 12)

The optical regime in electro-magnetic spectrum: characteristics, advantages/disadvantages, advantage over electronic system: faster, higher band width, economic, security etc., energy bands in solids, the E-k diagram, semiconductor optoelectronic materials, total internal reflection and scattering of light in attenuating medium, light propagation in wave guides.

Unit IV: Optical sources, medium, amplifier, transmitter (L 15, Marks15)

Source: LED, LASER, diode as lasing medium, LASER basics, LASER diode:
Device structure, materials and characteristics.

Medium: Optical fiber, classification, material and construction, properties, attenuation, dispersion (chromatic and anomalous), numerical aperture, modes of propagation, modal dispersion: Step index and graded index fibers, losses in fibers, different loss processes.

Detector: electroluminescence. photo detectors, semiconductor detectors, photo diode, P-I-N photodiode, avalanche photo diode (APD) and photo transistor, noise in photo-detection; detector performance characteristics

Semiconductor Optical Amplifiers & Modulators**:** Semiconductor optical amplifiers (SOA), SOA characteristics and some applications

Unit V: Optical communication system (L 10, Marks 9)
Basic architecture of an optical communication link, 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, attenuators, optical cross connects.

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 microcontroller based digital electronic circuits
2. Write assembly language programs for microprocessor and microcontroller controlled devices.
3. Analyze optical electronic devices
4. Critically analyze optical communication systems
5. Apply the knowledge of optical electronics to make innovative optical products for real life problem solving.

Suggested Readings:

1. The 8051 Microcontroller and Embedded system,Mazidi, Mazidi and McKinlay, Pearson Education
2. Optical Electronics,Ghatak and Thyagarajan, Cambridge University Press
3. Introduction to Fiber Optics, Ghatak and Thyagarajan, Cambridge University Press
4. Advanced Electronic Communication systems,W. Tomasi, PHI Learning Pvt.Ltd.
5. Microprocessor Architechture Programming and Applications with 8085, R. Gaonkar, PENRAM Publication.

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

Course Objectives:
Objective of the course is to

1. Introduce the Physics of the Earth's ionosphere.
2. Introduce the atmospheres of the solar system planets.
3. Introduce the Physics of the Sun.
4. Introduce radio astronomy.

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

Unit I: Physics of the Earth's Ionosphere (L 15, Marks 15)
Introduction, principle of formation, Chapman's hypothesis, ionization by energetic particles, X rays, chemical recombination, vertical transport, D, E, and F layers, ionospheres of the low and middle latitudes, in situ and remote measurement techniques-Langmuir probe, ionosonde, GPS

Unit II: Planetary Atmospheres (L 15, Marks 15)
Thermosphere-thermal structure, Exosphere-atmospheric escape, density distribution,
Physical properties of Planetary Atmospheres: Terrestrial planets, Jovian planets

Unit III: Physics of the Sun (L 15, Marks 15)
Structure of the Sun, solar wind, solar wind formation in the corona, solar wind interaction with the magnetosphere, solar cycle, solar flares, CME, Geomagnetic effect

Unit IV: Radio Astronomy (L 15, Marks 15)
Introduction, power, spectral power, brightness, discrete radio sources, flux density, blackbody radiation, Planck's law, radio sky, galactic radio noise, radio sources
Fundamentals of radio telescopes, GMRT

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 the student will be able to

1. Understand the basic plasma process in the Earth's ionosphere.
2. Acquainted with planetary atmospheres.

3. Learn about Sun, Solar wind, CME, solar wind interaction with the magnetosphere, Solar - Terrestrial environment.
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. Physics of Planetary Ionospheres, S J Bauer, Springer Verlag
4. Space Plasma Physics, A C Das, Narosa Publishing House
5. Radio Astronomy, J D Kraus, McGraw Hill

Course Code: PH-DSE-IVE
Course Title: Laser Spectroscopy II
Nature of the Course: DSE
Total Credit Assigned: 4
Distribution of credits: (L 3, T 1)

Course Objectives:
Objective of the course is to

1. Understand the basic principles of nonlinear spectroscopy
2. Familiarize with principles and instrumentations in modern nonlinear spectroscopy
3. Equip with the knowledge on different techniques of laser Raman spectroscopy and applications
4. Familiarize with recent developments in Laser Spectroscopy

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

Unit I: Nonlinear Spectroscopy (L 10, T 5 Marks 15)
Linear and nonlinear absorption, hole burning and lamb dips, Saturation spectroscopy, two photon and multi photon spectroscopy, polarization spectroscopy-basic principle and advantages, special techniques of nonlinear spectroscopy, Ionization spectroscopy, laser induced fluorescence

Unit II: Laser Raman Spectroscopy (L 10, T 5 Marks 15)
Tunable Raman lasers, Nonlinear Raman spectroscopy- stimulated Raman scattering, Coherent Anti-Stokes Raman Spectroscopy (CARS), hyper Raman effect, inverse Raman scattering, photo-acoustic Raman spectroscopy, spin-flip Raman spectroscopy, Applications of Laser Raman Spectroscopy

Unit III: Atom and ion optics (L 10, T 5 Marks 15)
Laser Cooling and Trapping of Atoms, slowing of atomic beams, Doppler cooling, Bose-Einstein condensation, Atom lasers, spectroscopy of single ions: ion trapping, Quantum jumps, Laser spectroscopy in storage rings, Atom interferometry

Ramsey fringes, squeezing and its application to gravitational wave detectors, Laser breakdown spectroscopy and its application

Unit IV: Coherent Spectroscopy (L 10, T 5 Marks 15)
Level crossing spectroscopy-Hanle Effect, quantum mechanical model, Quantum beat spectroscopy-basic principle and experimental technique, Photon echoes, correlation spectroscopy

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 the student will be able to

1. Understand and explain concepts in non linear spectroscopy
2. Demonstrate the use of modern laser spectroscopic instruments in practice
3. Demonstrate the advantages of use of laser spectroscopy in recent discoveries in Physics and various other areas
4. Use laser spectroscopic techniques in research.

Suggested Readings:

1. Laser Spectroscopy, W. Demtroder, Springer
2. Laser Fundamentals, W T Silfvast, Cambridge University press
3. Lasers and Non-linear Optics, B B Laud, New age international limited publishers
4. Principles of Fluorescence Spectroscopy, J.R. Lakowicz, Springer
5. High Resolution Spectroscopy, J.M. Hollas, John Wiley and Sons
6. Introduction to IR and Raman Spectroscopy, N. Colthup, L. Daly, S. Wiberley, Elsevier
7. Physics of Atoms and molecules, B.H. Brasden and C.J. Joachain, Prentice Hall.

Course Code: PH-DSE-VA
Course Title: Condensed Matter Physics Lab
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 Hall Effect and determine the different parameters.

Mode of Assessment/ Assessment Tools (%)

In Semester: 50	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	25
Viva Voce:	25
End Semester: 50	
Laboratory experiments:	50

(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, Pallav Chowdhury, New Age International
4. Solid State Physics, S.O. Pillai, New Age International

Course Code: PH-DSE-VB
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: 70% experiments need to be performed for claiming 4 credits. All analog experiments except the antenna radiation pattern 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 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 an RC low/high pass filter for 25/30 dB at different cut off frequencies. Ripple acceptance criteria to be changed for each set of students.
3. To design a Schmitt trigger comparator for given (e.g., 2V/3V, 1V/4V etc) LTP and UTP.
4. To use 8085 kit for arithmetic operations like addition, subtraction, division, multiplication, factoring etc. One additional experiment to be given to each student 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.
5. 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.
6. To use 8051 kit for arithmetic operations like addition, subtraction, division, multiplication, factoring etc. One additional experiment to be given to each student 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.
7. Study and characterization of single mode and multi-mode of optical fiber.
8. Measurement of optical fiber numerical aperture

Mode of Assessment/ Assessment Tools (%)

In Semester: 50

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	25
Viva Voce:	25
End Semester: 50	
Laboratory experiments:	50
(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

Suggested Readings:

1. The 8051 Microcontroller and Embedded system, Mazidi, Mazidi and McKinlay, Pearson Education
2. Electronic Principles A.P. Malvino Tata McGraw Hill
3. Op Amps and Linear Integrated Circuits R.K. Gaekwad, Prentice Hall of India
4. Microprocessor Architecture Programming & Applications with 8085, 2002, R.S. Goankar, Prentice Hall of India
5. Advanced Electronic Communication Systems, W. Tomasi, PHI Learning Pvt Ltd

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

Course Objectives:

1. To familiarise students with basic tools used in the study of Space Physics
2. To provide students with hands on training of parameters associated to Space Physics study

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 direct sense 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: 50	
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	25
Viva Voce:	25
End Semester: 50	
Laboratory experiments:	50
(One experiment from the list of experiments to be performed)	

Expected Learning Outcome:

After completion of the paper

1. A student will be able to operate basic tools like Ozonometer, aethalometer, scintillation monitor etc.
2. The hands on experience will enable a student to pursue further study in experimental Space Physics curriculum

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. Physics of Planetary Ionospheres, S J Bauer, Springer Verlag
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: Laser Spectroscopy Lab
Nature of the Course: DSE
Total credits assigned: 04
Distribution of credits: Lab-4

Course Objectives:

Objective of the course is to

1. Use and handle spectroscopic instruments in laboratory
2. Understand the principles of laser spectroscopy through performance of experiments
3. Provide exposure in practical application of spectroscopic instruments.

List of Experiments:

1. Frank-Hertz Experiment
2. To study the vibrational spectra of I_2 molecule
3. To determine the value of e/m by Zeeman effect
4. To record the absorption spectra of an optically active sample and hence determine the extinction coefficient and optical depth or path length of the sample
5. To record the photoluminescence spectra of an optically active sample and hence calculate the radiative parameters

Mode of Assessment/ Assessment Tools (%)

In Semester:	**50**
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	25
Viva Voce:	25
End Semester:	**50**
Laboratory experiments:	50

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

Expected Learning Outcome:

On completion of the course, the student will be able to:

1. Handle various spectroscopic instruments in laboratory and use those in research
2. Demonstrate the uses of various laser spectroscopic instruments in the fields of interest

Suggested Readings:

1. Laser Spectroscopy II, Experimental Techniques, W. Demtröder, Springer
2. Introduction to IR and Raman Spectroscopy, N. Colthup, L. Daly, S. Wiberley, Elsevier
3. Topics in Applied Physics, Vol-14, Laser Monitoring of the Atmosphere, Editor- E. D. Hinkley, Springer Berlin Heidelberg.
4. Physics of Atoms and molecules, B.H. Brasden and C.J. Joachain, Prentice Hall.

GENERIC ELECTIVE COURSES

Course Code: PH-GE-IA
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: PH-GE-IB
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.

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. 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

Suggested 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

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Course Code: PH-GE-IC
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 behaviour 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, Marks 10)
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, Marks 8)
Introductory concepts of magnetic materials, para-, dia-, and ferromagnetic materials.

Unit IV: Superconductivity (L 10, Marks 10)
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, Marks 12)
Introduction to nanomaterials, history and scope, interdisciplinary nature, surface to volume ratio, electronic structure, types of nanomaterials, applications 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)

Expected Learning 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

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-IIA
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 of thermodynamical properties of matter.
2. Understand the thermodynamics present in allied fields like Materials science, Condensed matter Physics, Atmospheric Physics, Solar Physics, etc.

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 in terms 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 Absolute Zero.

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 Outcome:

This course will enable the students to

1. Develop critical and analytical thinking on thermodynamics and allied disciplines.
2. Use the concept of thermodynamics in real world experiences.

Suggested Readings:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2^{nd} 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, 2^{nd} Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Course Code: PH-GE-IIB
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 Outcome:

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-IIC
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 charts.

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, 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
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-IID
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.

Suggested Readings:

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

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ABILITY ENHANCENENT COURSES

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

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), Inductive (LVDT) and piezoelectric transducers. Measurement of displacement, velocity and acceleration (translational and rotational), Particle detectors.

Unit III: Electronic instrumentation (L 10, Marks 10)
Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), shielding and grounding. Fourier transforms, lock-in detector, box-car integrator.

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 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. Familiarisation of Coordinate systems, telescopes and observational instruments (CCDs, filters, spectrographs)
3. Familiarisation of 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, multiwavelength astronomy (radio, x-ray, gamma-ray).

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 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

Suggested 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: 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. 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 Technique
Nature of the Course: AEC
Total Credit assigned: 2
Distribution of Credit: Theory-2

Course Objectives:

1. To introduce the theory of vacuum to the students.
2. Comprehension of thermal and flow behaviour of gases at very low pressures.
3. 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: 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. 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.

Suggested 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: Meteorological Fundamentals
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: 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 completion of the course, 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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Course Code: PH-AEC-IID
Course Title: Dissertation/ Project
Nature of the Course: AEC
Total Credit assigned: 2
