S. S. Jain Subodh P.G. College (Autonomous)
Jaipur

SYLLABUS

B.Sc. - Specialization
(Major – Physics)

(Semester Scheme)
Choice Based Credit System (CBCS)
[As Per The National Education Policy (NEP) – 2020]

I & II Semester Examinations 2025-2026
III & IV Semester Examinations 2026-2027
V &VI Semester Examinations 2027-2028
[Onwards]

S. S. Jain Subodh P.G. College (Autonomous), Jaipur
Bachelor of Science (B.Sc.) - Specialization
Major – Physics

Paper	Nomenclature of Paper	Credits	Max. Marks (EoSE)
Semester - I			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - I [DSC HPHY 101]	MECHANICS	04	70 Marks
PAPER - II [DSC HPHY 102]	ELECTRICITY & MAGNETISM	04	70 Marks
PHYSICS PRACTICAL LAB (I) - DSCP HPHY 111		04	60 Marks
Semester - II			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - III [DSC HPHY 201]	OSCILLATIONS & WAVES	04	70 Marks
PAPER - IV [DSC HPHY 202]	THERMAL & STATISTICAL PHYSICS	04	70 Marks
PHYSICS PRACTICAL LAB (II) - DSCP HPHY 211		04	60 Marks
Semester – III			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - V [DSC HPHY 301]	OPTICS	04	70 Marks
PAPER - VI [DSC HPHY 302]	MATHEMATICAL PHYSICS	04	70 Marks
PHYSICS PRACTICAL LAB (III) - DSCP HPHY 311		04	60 Marks
Semester – IV			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - VII [DSC HPHY 401]	ELEMENTARY QUANTUM MECHANICS	04	70 Marks
PAPER - VIII [DSC HPHY 402]	ELECTRONICS & SOLID STATE DEVICES	04	70 Marks
PHYSICS PRACTICAL LAB (IV) - DSCP HPHY 411		04	60 Marks
Semester – V			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - IX [DSC HPHY 501]	INTRODUCTORY NUCLEAR & PARTICLE PHYSICS	04	70 Marks
PAPER - X [DSC HPHY 502]	NUMERICAL METHODS & COMPUTER PROGRAMMING	04	70 Marks
PHYSICS PRACTICAL LAB (V) - DSCP HPHY 511		04	60 Marks
Semester – VI			
Paper	**Nomenclature of Paper**	**Credits**	**Max. Marks (EoSE)**
PAPER - XI [DSC HPHY 601]	PHYSICS OF MATERIALS	04	70 Marks
PAPER - XII [DSC HPHY 602]	ATOMIC & MOLECULAR PHYSICS	04	70 Marks
PHYSICS PRACTICAL LAB (VI) – DSCP HPHY 611		04	60 Marks

DSC = Discipline Specific Core; DSE = Discipline Specific Elective; DSCP = Discipline Specific Core Practical; SEM = Seminar; PRJ = Project Work; EoSE = End-of-Semester Examination; CIA = Continuous Internal Assessment. Marks Break-Up : End-of-Semester Exam (EoSE) (70 Marks) + Continuous Internal Assessment (CIA) (30 Marks); Total Marks Per Theory Paper = 100 Marks; Practical Exam Marks = 100 Marks (Internal 40 Marks + External 60 Marks); Grand Total of Marks Per Semester = 200 Marks (Theory) + 100 Marks (Practical) = 300 Marks.

Name of College	**S.S. Jain Subodh P.G. College (Autonomous), Jaipur**
Name of Faculty	**Science**
Name of Programme	**Under Graduate (U.G.) : B.Sc. - Specialization**
Name of Discipline	**Major Discipline - Physics**

PROGRAMME PREREQUISITES

Physics and Mathematics courses of Central Board of Secondary Education or equivalent.

PROGRAMME OUTCOMES (POs)

1. Proficiency in Scientific Principles : Students will demonstrate a strong understanding of fundamental scientific principles in physics and mathematics. They will be able to apply these principles to analyse and solve complex problems.
2. Analytical and Critical Thinking : Students will develop analytical and critical thinking skills through the study of physics and mathematics. They will be able to evaluate and interpret data, formulate hypotheses, and draw logical conclusions based on evidence.
3. Quantitative and Computational Skills : Students will acquire proficiency in quantitative and computational methods. They will be able to perform calculations, manipulate mathematical expressions, and use computational tools to solve scientific problems.
4. Experimental and Laboratory Skills : Students will gain hands-on experience in conducting experiments, using laboratory equipment, and analysing experimental data. They will understand the importance of accurate measurement, data interpretation, and documentation.
5. Problem Solving and Modelling : Students will develop problem-solving skills and the ability to create mathematical models to represent real-world phenomena. They will apply mathematical and scientific concepts to formulate and solve problems in physics, chemistry, and related fields.
6. Interdisciplinary Understanding : Students will develop an interdisciplinary perspective by integrating concepts from physics, chemistry, and mathematics. They will understand the connections and interdependencies among these disciplines and their applications in other scientific and technological areas.
7. Effective Communication : Students will develop effective oral and written communication skills. They will be able to communicate scientific ideas, theories, and experimental results clearly and concisely to both technical and non-technical audiences.
8. Ethical and Professional Responsibility : Students will understand and adhere to ethical and professional standards in scientific research and practice. They will demonstrate integrity, responsible conduct, and respect for intellectual property.
9. Lifelong Learning : Students will recognize the importance of lifelong learning and professional development. They will be motivated to pursue further studies, engage in research, and keep up with advancements in physics, chemistry, and mathematics.
10. Teamwork and Collaboration : Students will develop teamwork and collaboration skills through group projects, laboratory work, and research activities. They will be able to work effectively in diverse teams and contribute to collective goals.

Scheme of Examination-

1 Credit = 25 Marks For Examination/Evaluation

Continuous assessment in which sessional work and the terminal examination will contribute to the final grade. Each course in Semester Grade Point Average (SGPA) has two components- Continuous Internal Assessment (CIA) (30% weightage) and End of Semester Examination (EoSE) (70% weightage).

1. Sessional work will consist of class tests, mid-semester examination(s), homework assignments, etc., as determined by the faculty in charge of the courses of study.
2. Each Paper of EoSE shall carry 70% of the total marks of the course/subject. The EoSE will be of 3 hours duration. Each question will carry equal marks and the paper will consist of two parts given as follows :
   - Part A of the paper shall have multiple questions of equal marks. This first question shall be based on knowledge, understanding and applications of the topics/texts covered in the syllabus.
   - Part B of the paper shall consist of 4 questions from with an internal choice in each of the units. The four questions will be set with one from each of the units with internal choice. Third to fourth questions shall be based on applications of the topics/texts covered in the syllabus (60% weightage) and shall involve solving Problems (40% weightage), if applicable.
3. 75% Attendance is mandatory for appearing in EoSE.
4. To appear in the EoSE examination of a course/subject student must appear in the mid-semester examination and obtain at least a "C" grade in the course/subject.
5. Credit points in a Course/Subject will be assigned only if, the student obtains at least a C grade in midterm and EoSE examination of a Course/Subject.

Contact Hours –

15 Weeks per Semester

L – Lecture	(1 Credit = 1 Hour/Week)
T – Tutorial	(1 Credit = 1 Hour/Week)
S – Self-Study	(1 Credit = 2 Hours/Week)
P – Practical/Practicum	(1 Credit = 2 Hours/Week)
F – Field Practice/Projects	(1 Credit = 2 Hours/Week)
SA – Studio Activities	(1 Credit = 2 Hours/Week)
I – Internship	(1 Credit = 2 Hours/Week)
C – Community Engagement and Service	(1 Credit = 2 Hours/Week)

Exit and Entrance Policy

1. Students who opt to exit after completion of the first year and have secured 12 credits will be awarded a **UG Certificate** if, in addition, they complete one internship of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within two years and complete the degree programme within the stipulated maximum period of six years.
2. Students who opt to exit after completion of the second year and have secured 24 credits will be awarded the **UG diploma** if, in addition, they complete one internship of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of two years and complete the degree programme within the maximum period of six years.

3. Students who wish to undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 36 credits and satisfying the minimum credit requirement.
4. A four-year UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 84 credits and have satisfied the minimum credit requirements.
5. Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 84 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

Letter Grades and Grade Points

Letter Grade	Grade Point	Marks Range (%)
O (outstanding)	10	91 - 100
A+ (Excellent)	9	81 - 90
A (Very good)	8	71 - 80
B+ (Good)	7	61 - 70
B (Above average)	6	51 - 60
C (Average)	5	40 - 50
P (Pass)	4	
F (Fail)	0	
Ab (Absent)	0	

When students take audit courses, they may be given a pass (P) or fail (F) grade without any credits.

S. S. Jain Subodh P.G. College (Autonomous), Jaipur
B.Sc. – Specialization
Major – Physics

Examination Scheme For Each Paper – Choice Based Credit System (CBCS)

As Per

The National Education Policy (NEP) 2020

Part A 7 QUESTIONS (Very Short Answer Questions Out of 10) **7 X 2 MARKS EACH = 14 Marks**

Part B 4 QUESTIONS
(1 Question From Each Unit With Internal Choice) **4 X 14 MARKS EACH = 56 Marks**

Maximum Marks of End-Semester Exam (Duration of Exam = 3 Hours) = 70 Marks

Continuous Internal Assessment (CIA) Exam Marks = 30 Marks

Maximum Marks (Each Theory Paper) = 100 Marks

Maximum Practical Exam Marks = 100 Marks
[Internal Practical Exam Marks = 40; External Practical Exam Marks = 60 Marks]

Total of Theory Papers = 2 x 100 Marks Each = 200 Marks

(Minimum Pass Marks 40% = 40 Marks Per Paper)

Grand Total of Marks Per Semester = 200 Marks (Theory) + 100 Marks (Practical)

= 300 Marks

Program : Bachelor of Science (B.Sc.) - Specialization, Major : Physics

Semester	Type	Paper code & Nomenclature	Credits	Duration of Examination	Max. Marks (CIA, EoSE)	Min. Marks (CIA + EoSE) (Put Together)
I	T	DSC HPHY 101 - Mechanics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 102 – Electricity & Magnetism	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 111 – Physics Practical Lab (I)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks
II	T	DSC HPHY 201 – Oscillations & Waves	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks - CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 202 – Thermal & Statistical Physics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 211 - Physics Practical Lab (II)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks
III	T	DSC HPHY 301 - Optics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 302 – Mathematical Physics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 311 - Physics Practical Lab (III)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks
IV	T	DSC HPHY 401 – Elementary Quantum Mechanics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 402 - Electronics & Solid-State Devices	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 411 - Physics Practical Lab (IV)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks
V	T	DSC HPHY 501 – Introductory Nuclear & Particle Physics	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 502 - Numerical Methods & Computer Programming	04	1 Hr – CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 511 - Physics Practical Lab (V)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks
VI	T	DSC HPHY 601 – Physics of Materials	04	1 Hr - CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	T	DSC HPHY 602 – Atomic & Molecular Physics	04	1 Hr - CIA 3 Hrs – EoSE	30 Marks – CIA 70 Marks – EoSE	40 Marks
	P	DSCP HPHY 611 - Physics Practical Lab (VI)	04	2 Hrs – Int. 3 Hrs – Ext.	40 Marks – Int. 60 Marks – Ext.	40 Marks

DSC = Discipline Specific Core; DSCP = Discipline Specific Core Practical; DSE = Discipline Specific Elective; T = Theory; P = Practical; EoSE = End-of-Semester Examination; CIA = Continuous Internal Assessment (Mid-Term Test), PHY = Physics; Int. = Internal; Ext. = External.

Student needs to complete two core theory courses (DSC HPHY) of 04 credits each along with core physics laboratory practicals (DSCP) of 04 credits per semester for six semesters.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - I

Paper (I) - Mechanics

(DSC HPHY 101, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	DSC HPHY 101	Mechanics	5	04
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of mechanics, including the laws of motion, frames of reference, mechanics of a system of particles motion under central forces, motion of particles, rigid body dynamics and elastic properties. The course aims to develop their knowledge and skills in analysing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts. The objective of the course is to provide students with knowledge related to mechanics. The lab aims to reinforce theoretical concepts learned in the classroom, develop conceptual skills, and enhance the understanding of physics principles both through sharpened theoretical skills & experimentation.			

Unit - I : Inertial & Non-Inertial Frames, Special Theory of Relativity, Coriolis Force

Inertial & Non-Inertial Frames : Inertial and non-inertial frames of reference, Explanation with examples, Transformation of displacement, velocity and acceleration between different frames of reference involving translation, Invariance of Newton's laws and energy conservation in a collision process.

Special Theory of Relativity : Postulates of the Special Theory of Relativity, Lorentz transformations of velocity and acceleration, Time dilation and length contraction.

Coriolis Force : Transformation of displacement, velocity and acceleration between different frames rotating with respect to each other, Pseudo forces, Centrifugal and Coriolis forces, Motion relative to earth (in northern and southern hemispheres) and position of latitude, Effect of Coriolis force on various bodies in motion on earth, Foucault's pendulum. **(15 Lectures)**

Unit - II : Conservation Laws, Mechanics of A System of Particles

Conservation Laws : Conservative forces, Potential energy in gravitational and electrostatic field, Rectilinear motion under conservative forces, Discussion of potential energy curve and motion of a particle, Centre of mass, Two particle system : Motion of the centre of mass (CM) and motion of one particle relative to another, Reduced mass, Conservation of linear momentum, Collision of two particles in one and two dimensions (elastic and inelastic).

Slowing down of neutrons in a moderator, Motion of a system with varying mass, Angular momentum conservation and charged particle scattering by a nucleus.

Mechanics of A System of Particles : Motion of the centre of mass of a system of particles, Motion relative to CM, Relationship for kinetic energy and angular momentum of a system of particles in the lab frame and the CM frame, Conservation of energy, Equation of rotational motion of a system of particles, Conservation of angular momentum. **(15 Lectures)**

Unit - III : Gravitation & Motion Under Central forces, Relativistic Kinetics

Gravitation & Motion Under Central forces : Law of gravitation, Gravitational and inertial mass, Gravitational potential energy and gravitational field, Principle of superposition, Gravitational field due to a large plate, Spherical shell and sphere.

General motion under central forces, General solution and discussion of trajectories, Rutherford scattering case of elliptical and circular orbits, Kepler's Laws.

Relativistic Kinetics : Lorentz transformations as rotation in space-time, World line and Minkowski space, Time-like and space like vectors, Macro-causality, Light cone and past, present and future, Four vectors, Transformation of energy and momentum, Transformation between lab and CM frames, Transformation of four frequency vectors and longitudinal and transverse Doppler effect, Four momentum conservation, Elastic and inelastic collision of a system of two particles, Kinematics of decay products of an unstable particle, Reaction threshold energy, Pair production, Compton effect. **(15 Lectures)**

Unit - IV : Rigid Body Dynamics, Elastic Properties

Rigid Body Dynamics : Equation of motion of a rotating body, Inertial coefficients, Moment of inertia of a disc, cylinder, spherical shell, sphere, and rod of rectangular and circular cross-sections, Case of J not parallel to ω, Kinetic energy of rotation and principal axes, Precessional motion of the spinning top, Gyroscope, Spin precession in the constant magnetic field.

Elastic Properties : Elasticity, Young's modulus, Bulk modulus, Modulus of rigidity, Poisson's ratio and derivation of relations between various classical constants, Bending of a beam, Torsion of a cylinder, Experimental determination of elastic constants by static and dynamical methods. **(15 Lectures)**

Reference Books/Text Books

1. Mechanics by Charles Kittel, Berkeley Physics Course.
2. Introduction to Classical Mechanics by R. G. Takwale, P S. Puranik, TMH.
3. Classical Mechanics by Herbert Goldstein, Pearson Education.
4. Classical Mechanics by Dr. J. C. Upadhyaya, Himalaya Publishing House.
5. Analytical Mechanics by Louis N. Hand, Janet D. Finch, Cambridge University Press.
6. Mechanics by L.D. Landau and E. M. Lifshitz, Elsevier.
7. An Introduction To Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
8. Mechanics, D. S. Mathur, S. Chand and Company Limited.
9. Mechanics, Berkeley Physics, Vol.1, Kittel, Knight, et.al. 2007, Tata McGraw-Hill.
10. Course of Theoretical Physics, Vol-I Mechanics, L.D. Landau, E.M. Lifshitz, Butterworth-Heinemann.

Suggested E-Resources :

1. MIT OpenCourseWare: Classical Mechanics - This resource provides lecture notes, problem sets, and solutions for a complete course on classical mechanics: https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in mechanics: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
3. MIT OpenCourseWare : Oscillations & Waves - This resource provides lecture notes, problem sets, and solutions for a complete course on oscillations & waves : https://ocw.mit.edu/courses/res-8-009-introduction-to-oscillations-and-waves-summer-2017/
4. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in oscillations & waves : http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understand the concept of inertial and non-inertial frames of reference and their implications on the laws of motion.
2. Apply transformations of displacement, velocity, and acceleration between different frames of reference involving translation.
3. Explain the Galilean transformation and the invariance of Newton's laws.
4. Interpret Lorentz transformations as rotations in space-time, understand the concepts of world line and Minkowski space, and analyze time-like and space-like vectors.
5. Discuss the concept of causality, light cones, and the division of past, present, and future events.
6. Apply transformations of displacement, velocity, and acceleration between frames rotating with respect to each other, analyze pseudo forces, centrifugal and Coriolis forces, and their effects on various bodies in motion.
7. Analyze the motion in rotating frames, including the transformation of displacement, velocity, and acceleration, and the effects of pseudo forces such as the Coriolis force.
8. Analyze the motion of a Foucault pendulum and understand its relation to the rotation of the Earth.
9. Define conservative and non-conservative forces and analyze rectilinear motion under conservative forces.
10. Analyze potential energy curves and understand the motion of particles under conservative forces.
11. Explain the concept of the center of mass and its relevance in the motion of systems of particles.
12. Apply the concept of conservation of angular momentum and analyze particle scattering by a nucleus.
13. Understand the equations of motion for rotating bodies and the concept of the moment of inertia.
14. Analyze the kinetic energy of rotation and the motion of spinning tops.
15. Understand the motion under central forces, including gravitational interaction, and apply Kepler's laws.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - I

Paper (II) – Electricity & Magnetism

(DSC HPHY 102, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	DSC HPHY 102	Electricity & Magnetism	5	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of electrostatics. It aims to develop their knowledge and skills in analysing scalar and vector fields, electric fields, and their interactions. The course will also cover important topics such as electric potential and polarization. The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of electromagnetism. It aims to develop their knowledge and skills in electric and magnetic fields, and their interactions, as described by Maxwell's equations. The course will also cover important topics such as electric potential, polarization, magnetostatics, and electromagnetic waves.			

Unit - I : Scalar & Vector Fields, Field of Moving Charges

Scalar &Vector Fields : Partial derivative, Gradient of scalar field function, Line integral of a vector field, Divergence in cartesian coordinates, Gauss's divergence theorem, Physical meaning of divergence of a vector, Concept of solid angle, Gauss's law from inverse square law, Gauss's law in differential forms, Poisson's & Laplace's equations, Curl of a vector function, Curl in cartesian coordinates, Stoke's theorem : Physical meaning of the curl of a vector, Vector identities using del operator.

Field of Moving Charges : Concept of electrostatic-field and electric-potential due to discrete charges and continuous charge distribution, Potential energy of a system of charges, Applications : Energy required to build a uniformly charged sphere, Classical radius of an electron, Potential and field due to a short dipole (in polar and three-dimensional (3D) cartesian coordinates), Torque and force on a dipole in an external field. **(15 Lectures)**

Unit - II : Magnetic Force Field, Magnetic Field In Free Space And Matter

Magnetic Force Field : Magnetic forces, Measurement of charge in motion, Invariance of charge, Electric field measured in different frames of reference, Field of a point charge moving with constant velocity, Force on a moving charge, Interaction between moving charge and other moving charges.

Magnetic Field In Free Space And Matter : Definition of magnetic field, Properties of the magnetic field, Ampère's circuital law with applications, Ampère's law in differential form, Vector potential, Poison's equation for vector potential, Vector potential and evaluation of B for (i) a current in an infinite solenoid (ii) outside a current carrying long straight wire (iii) inside a long straight wire carrying uniform current, Field of any current carrying wire and deduction of Biot-Savart's law.

Transformation relations for different components of electric and magnetic fields between two inertial frames.

Field of a current loop, Force on a magnetic dipole in an external field, Electric currents in atoms, Bohr magneton, Orbital gyromagnetic ratio, Electron spin and magnetic moment, Magnetic susceptibility, Magnetic field caused by magnetized matter, Magnetization current, Free currents and the field H. **(15 Lectures)**

Unit - III : Electric Field in Matter

Electric Field In Matter : Electrical moments of a system of discrete charges and continuous charge distribution, Dipole and quadrupole moments of discrete charge distribution, Simple examples, Atomic & molecular-dipoles, Atomic polarizability, Permanent dipole moments, Dielectrics, Capacitor filled with a dielectric, Potential and field due to a polarized sphere, Dielectric sphere placed in uniform field, Field of a charge in dielectric medium and Gauss's law, Connection between electric susceptibility & atomic polarizability, Polarization in changing fields, Bound charge (polarization) current. **(15 Lectures)**

Unit - IV : Electromagnetic Induction (EMI)

EMI : Faraday's law of electromagnetic induction (EMI), Conducting rod moving through a uniform magnetic field, Differential form of Faraday's law, Inductance, Self-inductance of a solenoid of finite length, Mutual inductance, Mutual inductance between two coils, Self-inductance of a straight conductor, Energy stored in an inductor and in the magnetic field, Displacement current, Modified Ampere's law, Maxwell's equations-in-differential and integral forms. **(15 Lectures)**

Reference Books/Text Books

1. Electricity & Magnetism by A.S. Mahajan & Abbas A. Rangwala Tata McGraw-Hill.
2. Introduction to Electrodynamics by David J. Griffith, Prentice Hall of India Pvt. Ltd. New Delhi.

3. Fundamental University Physics Vol II: Fields and Waves by Alonso/Finn, Addison – Wesley Publishers.
4. Classical Electrodynamics by J. D. Jackson, Wiley Student Edition.
5. Classical Electrodynamics : A Modern Perspective by Kurt Lechner, Springer International Publishing AG.
6. Classical Electrodynamics by P. Sengupta, New Age International Publishers.
7. Classical Electrodynamics (Revised Edition) by S. P. Puri, Narosa Publishers.

Suggested E-Resources

1. MIT OpenCourseWare: Electrostatics - This resource offers lecture notes, assignments, and exams for a complete course on electrostatics : https://ocw.mit.edu/courses/physics/8-02sc-physics-ii-electricity-and-magnetism-spring-2011/
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in electrostatics and electric fields: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elefie.html
3. MIT OpenCourseWare : Electricity and Magnetism - This resource offers lecture notes, assignments, and exams for a complete course on electricity and magnetism: https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/
4. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in electromagnetism : http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Course Learning Outcomes:

By the end of the course, students should be able to:

1. Understand the concept of scalar and vector fields and their physical significance, demonstrate knowledge of gradient, divergence, and curl operators and their applications in electromagnetism.
2. Apply Gauss divergence and Stoke's theorems to analyze electric and magnetic fields, explain the behavior of electric fields and potential energy in different charge distributions, analyze the interaction of electric dipoles with external electric fields and calculate the resulting potentials, solve problems related to Poisson's and Laplace's equations in electrostatics.
3. Describe the behavior of electric fields in different types of matter, including dielectrics and polarized spheres, understand the concept of electric displacement, susceptibility, and dielectric constant, understand the concept of vector fields and their mathematical representation. Calculate partial derivatives, gradients, and line integrals of scalar and vector fields.
4. Apply Gauss's divergence theorem and understand the physical meaning of divergence in Cartesian coordinates. Relate divergence to the concept of solid angle and Gauss's law.
5. Apply curl to vector fields and understand its physical significance. Use Stoke's theorem to relate curl to line integrals. Manipulate vector identities using the del operator and understand their applications in physics.
6. Analyze electrostatic fields and potentials due to discrete charges and continuous charge distributions. Calculate potential energy of systems of charges. Apply the concept of electrostatic potential to determine the energy required to build a uniformly charged sphere and the classical radius of an electron.
7. Analyze the potential and field due to a short dipole in polar and Cartesian coordinates. Calculate the torque and force on a dipole in an external field.
8. Investigate magnetic forces, the measurement of charge in motion, and the invariance of charge. Analyze the electric field measured in different frames of reference. Analyze the behavior of magnetic fields in various materials and the effects of currents on magnetic fields.
9. Apply Ampere's law and the magnetic vector potential to calculate magnetic fields in different scenarios. Explain the properties of electromagnetic waves and their behavior in isotropic and dispersive media.
10. Calculate the energy density and radiation pressure of electromagnetic waves, understand the spectrum of electromagnetic waves and its implications, investigate magnetic forces, the measurement of charge in motion, and the invariance of charge. Understand the magnetic field in free space and matter. Apply Ampère's circuital law and use it in differential form with the vector potential.
11. Study electric fields in matter, including electrical moments, dipole and quadrupole moments, atomic and molecular dipoles, and dielectrics. Analyze the field of a charge in a dielectric medium and the connection between electric susceptibility and atomic polarizability.
12. Investigate electromagnetic induction, Faraday's law, and the effects of conducting rods and loops moving in magnetic fields. Understand the differential and integral forms of Faraday's law.
13. Analyze inductance, self-inductance, mutual inductance, and energy stored in inductors and magnetic fields. Understand displacement current and its role in Maxwell's equations.
14. Explore Maxwell's equations in differential and integral form, their application in material media, and the boundary conditions for electric and magnetic fields at vacuum-dielectric and vacuum-metal boundaries.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - I

Physics Practical Lab (I)

(DSCP HPHY 111, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
I	DSCP HPHY 111	Physics Practical Lab (I)	5	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Practical, One Hundred And Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	1. To provide hands-on experience in conducting experiments related to electricity and magnetism. 2. To develop practical skills in using various electrical components and instruments. 3. To reinforce theoretical concepts learned in the corresponding lecture course through practical applications. 4. To enhance problem-solving and analytical skills by analysing experimental data and interpreting results. 5. To promote scientific inquiry, critical thinking, and the ability to design and execute experiments. 6. To foster teamwork and collaboration in conducting experiments and analysing results. 7. To develop skills in accurately measuring and recording experimental data.			

DSCP HPHY 111 : Physics Practical Lab (I)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis. Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - I

1. To convert galvanometer into an ammeter of a given range.
2. To convert galvanometer into a voltmeter of a given range.
3. To study the variation of power transfer to different loads by a D.C. source and to verify maximum power transfer theorem.
4. To study the transient behaviour of a RC circuit using a DC source by varying values of R and C.
5. To study the characteristics of a semiconductor junction diode and determine forward and reverse resistances.
6. To determine the specific resistance of the material of a wire using Carey Foster's bridge.
7. To determine the difference between two small resistances using Carey Foster's bridge.
8. To study the resonance frequency of series LCR circuit and hence to determine resonance frequency, quality factor & bandwidth.
9. To study the resonance of parallel LCR circuit and hence to determine resonance frequency, quality factor & bandwidth.
10. To study the rise and decay of current in an L-R circuit with a source of constant EMF and to determine the time constant.
11. To study the behaviour of an RC Circuits with varying resistance and capacitance using AC mains as a power source and also to determine the impedance and phase relations.
12. To study the voltage and current behavior of an LR circuit with an AC power source. Also, determine power factor, impedance and phase relations.
13. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Demonstrate proficiency in using various electrical components and instruments required for conducting experiments.
2. Apply theoretical concepts of electricity and magnetism to design and execute experiments.
3. Analyze experimental data using appropriate mathematical and statistical techniques.
4. Interpret experimental results and draw conclusions based on data analysis.
5. Develop skills in accurately measuring physical quantities and recording experimental observations.
6. Communicate experimental procedures, results, and conclusions effectively in written reports.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - II

Paper (III) - Oscillations & Waves

(DSC HPHY 201, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks: 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	DSC HPHY 201	Oscillations & Waves	5	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of oscillations & waves in a broader framework. The course aims to develop their knowledge and skills in analysing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts. The objective of the course is to provide students with knowledge related to oscillations & waves. The lab aims to reinforce theoretical concepts learned in the classroom, develop conceptual skills, and enhance the understanding of physics principles both through sharpened theoretical skills & experimentation.			

Unit - I : Free Oscillations, Oscillations In An Arbitrary Potential Well, SHM, Superposition of Undamped Harmonic Oscillators

Free oscillations of systems with one degree of freedom, Oscillations in an arbitrary potential well, Simple harmonic motion-solution using complex exponentials, Examples of mechanical and electrical systems, Superposition of (i) two and (ii)-N-linear undamped harmonic oscillations, Energy of oscillator, Power Dissipation, Quality factor & damping of the oscillator under viscous and solid friction. **(15 Lectures)**

Unit - II : Forced Oscillations With Damping, Power of An Oscillator, Resonance, Series & Parallel LCR Circuits, Ballistic Galvanometer, Anharmonic Oscillators

Undamped oscillator with harmonic force, Forced oscillations with damping, Effect of varying the resistive term, Transient phenomenon, Power absorbed by a driven oscillator, Frequency response, Phase relations, Quality factor, Resonance : Electrical oscillations, Series and parallel LCR circuit.

Electromechanical system : Ballistic galvanometer, Effect of damping, Anharmonic oscillator – Pendulum as an example. **(15 Lectures)**

Unit - III : Two-Coupled & Many-Coupled Oscillators

Two-Coupled Oscillators : Motion of the two coupled simple harmonic oscillators, Coupled oscillators; Normal modes, Motion in mixed mode, Transient behaviour, Effect of coupling, Normal modes of vibration of CO_2 and H_2O molecules, Calculation of normal modes : Forced oscillations and resonance for two coupled oscillators, Electrically coupled circuits : frequency response, Reflected impedance effect of coupling (inductive case) and resistive loads.

Many Coupled Oscillators : N-coupled oscillators, Normal modes and their properties, Longitudinal oscillators, Equation of motion for one dimensional (1D) monoatomic and diatomic lattices, Acoustic and optical modes, Dispersion relations, Concept of group and phase-velocities. **(15 Lectures)**

Unit - IV : Wave Equation In Different Dimensions, Electromagnetic (EM) Waves

Wave Equation In Different Dimensions : Wave equation in one dimension (1D) and its solution for elastic waves in solid rod, Gas column, Transverse waves on a string, Normal modes of a two-dimensional (2D) system, Waves in two (2D) and three (3D) dimensions, Spherical waves, Fourier series & analysis of triangular sawtooth & square functions.

Reflection and transmission of waves on a string at a boundary, Reflection and transmission of energy, Standing waves on a string of fixed length, Standing wave ratio (SWR), Energy of a vibrating string.

Electromagnetic (EM) Waves : Plane electromagnetic (EM) waves equation and its plane wave solution, Energy & momentum, Radiation pressure, Radiation resistance of free space, EM wave in dispersive media (normal case), Spectrum of electromagnetic radiations. **(15 Lectures)**

Reference Books/Text Books

1. The Physics of Wave and Oscillation by N.K. Bajaj, McGrow Hill Education.
2. Vibration and Waves by A. P. French, CBS Publishers.
3. The Physics of Vibrations and Waves by H. J. Pain, 6th Ed., John Wiley & Sons Ltd.
4. Waves and Oscillation, Berkeley Physics Course Vol.3.
5. Mechanics by Charles Kittel, Berkeley Physics Course.
6. Introduction to Classical Mechanics by R. G. Takwale, P S. Puranik, TMH.
7. Classical Mechanics by Herbert Goldstein, Pearson Education.
8. Classical Mechanics by Dr. J. C. Upadhyaya, Himalaya Publishing House.
9. Analytical Mechanics by Louis N. Hand, Janet D. Finch, Cambridge University Press.
10. Mechanics by L.D. Landau and E. M. Lifshitz, Elsevier.
11. An Introduction To Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
12. Mechanics, D. S. Mathur, S. Chand and Company Limited.
13. Mechanics, Berkeley Physics, Vol.1, Kittel, Knight, et.al. 2007, Tata McGraw-Hill.

14. Course of Theoretical Physics, Vol-I Mechanics, L.D. Landau, E.M. Lifshitz, Butterworth-Heinemann.

Suggested E-Resources :

1. MIT OpenCourseWare: Classical Mechanics - This resource provides lecture notes, problem sets, and solutions for a complete course on classical mechanics: https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in mechanics: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
3. MIT OpenCourseWare : Oscillations & Waves - This resource provides lecture notes, problem sets, and solutions for a complete course on oscillations & waves : https://ocw.mit.edu/courses/res-8-009-introduction-to-oscillations-and-waves-summer-2017/
4. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in oscillations & waves : http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Course Learning Outcomes :

By the end of the course, students should be able to :

1. Analyze damped harmonic oscillations and understand the effects of damping on oscillatory motion.
2. Analyze driven harmonic oscillators with damping and understand frequency response and power dissipation.
3. Explain the behavior of coupled oscillators and analyze systems of oscillators with neighbor interactions.
4. Understand the concept of free oscillations and analyze systems with one degree of freedom. Study oscillations in arbitrary potential wells and solve simple harmonic motion problems using complex exponentials.
5. Analyze mechanical and electrical systems undergoing oscillatory motion. Calculate the energy of oscillators and examine power dissipation and damping under viscous and solid friction.
6. Understand the superposition of two undamped harmonic oscillations and the concept of beats. Analyze the combination of two oscillations at right angles and study anharmonic oscillators using the pendulum as an example.
7. Study forced oscillations with damping and harmonic forces. Analyze the effect of varying the resistive term and understand transient phenomena in driven oscillators. Calculate power absorbed by a driven oscillator and examine frequency response, phase relations, and quality factor.
8. Explore resonance in electrical oscillations, series and parallel LCR circuits, and electromechanical systems, such as, ballistic galvanometers. Study non-linear effects in electrical devices and acoustic waves.
9. Analyze the motion of two coupled simple harmonic oscillators and derive the differential equations for stiffness or capacitance-coupled oscillators. Understand normal modes and motion in mixed modes.
10. Study the normal modes of vibration for molecules and electrically coupled circuits.
11. Investigate many coupled oscillators, including N-coupled oscillators and longitudinal oscillators.
12. Understand the concept of normal modes, calculate normal mode frequencies, and study the motion of monoatomic and diatomic lattices. Explore dispersion relations, group and phase velocities, and the effects of coupling.
13. Study the wave equation in one dimension and its solutions for elastic waves in solid rods, gas columns, and transverse waves on a string. Analyze normal modes of a two-dimensional system and waves in two and three dimensions, including spherical waves.
14. Understand the reflection and transmission of waves on a string at a boundary, including the reflection and transmission of energy. Analyze impedance matching and standing waves on a string of fixed length.
15. Calculate the energy of a vibrating string and analyze the energy in each normal mode.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - II

Paper (IV) – Thermal & Statistical Physics

(DSC HPHY 202, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note : There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	DSC HPHY 202	Thermal & Statistical Physics	5	04
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of thermodynamics. It aims to develop their knowledge and skills in analyzing general thermodynamical interactions, theory & application of Clausius-Clapeyron equation, Carnot's theorem, Maxwell relations, production and applications of low temperatures & superconductors.			

Unit - I : Thermal & Adiabatic Interactions, Zeroth Law, General Thermodynamical Interaction, Carnot's Engine, Clausius-Clapeyron Equation & Maxwell's Relations

Thermal And Adiabatic Interactions : Thermal interaction, Zeroth law of thermodynamics, Systems in thermal contact with a heat-reservoir (canonical distribution), Energy Fluctuations, Entropy of a system in a heat bath, Helmholtz free energy, Adiabatic interaction and enthalpy, General interaction & first law of thermodynamics, Infinitesimal general interaction, Gibb's free energy, Phase transitions, Triple point, First and second-order phase transitions, Clausius-Clapeyron equation, Vapour pressure curve, Transformation of disorder into order, Heat engine & efficiency of engine, Carnot's Cycle, Thermodynamic scale as an absolute scale, Maxwell relations and- their applications. **(15 Lectures)**

Unit - II : Kinetic Theory & Transport Phenomenon

Kinetic Theory : Derivation of Maxwell's law of distribution of velocities and its experimental verification, Most probable, average and RMS velocities, Diffusion, Equipartition theorem.

Transport Phenomenon : Mean free path, Distribution of free path, Coefficients of viscosity, Thermal conductivity & diffusion, Brownian motion. **(15 Lectures)**

Unit - III : Production of Low Temperatures & Classical Statistics

Production of Low Temperatures : Cooling by adiabatic expansion, Coefficient of performance, Joule Thomson effect, J-T coefficient for ideal as well as Van der Waal's gases, Porous plug experiment, Temperature of inversion, Regenerative cooling, Air Liquefiers, Adiabatic demagnetization of paramagnetic substances : Nuclear paramagnetism, Liquid He I and He II, Superfluidity, Quest for absolute zero, Third law of thermodynamics & Nernst's heat theorem.

Classical Statistics : Validity of classical approximation, Phase space, Micro & Macro states, Thermodynamic probability, Entropy and probability, Monoatomic ideal gas, Barometric equation, Specific heat of diatomic gas, Ortho- & para-hydrogen, Specific heat capacity of solids. **(15 Lectures)**

Unit - IV : Quantum Statistics

Quantum Statistics : Bose-Einstein and Fermi-Dirac distribution laws, Calculation of the thermodynamic functions of weak degenerate gas, Strong degeneration, Calculation of the thermodynamic functions of an ideal Bose gas, Derivation of Planck's law, Flux of radiation energy, Radiation pressure, Thermodynamic functions of an ideal Fermi electron gas, Free electron model for metals, Spectra of metals, Richardson's equation of thermionic emission. **(15 Lectures)**

Reference Books/Text Books

1. Thermal Physics by Kittel, San Francisco: W.H. Freeman Publisher.
2. Statistical and Thermal Physics by S Lokanathan, R S Gambhir, PHI Learning Publisher.
3. Statistical Physics by Berkeley Series Vol. V, McGraw Hill India.
4. Fundamentals of Statistical and Thermal Physics by F. Reif, Sarat Book House.
5. An Introduction To Thermodynamics by Y. V. C. Rao, Universities Press.
6. Thermodynamics : A Complete Undergraduate Course by Andrew M. Steane, OUP Oxford.
7. Thermodynamics (Foundations & Applications) by E. P. Gyftopoulos & G. P. Beretta, Dover Publications.

Suggested E-Resources :

1. MIT OpenCourseWare: Thermodynamics - This resource offers lecture notes, assignments, and exams for a complete course on thermodynamics : https://ocw.mit.edu/courses/5-60-thermodynamics-kinetics-spring-2008/
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in thermodynamics : http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
3. MIT OpenCourseWare: Statistical Physics - This resource provides lecture notes, problem sets, and solutions for a complete course on statistical physics : https://ocw.mit.edu/search/?q=statistical%20physics
4. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in statistical physics : http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/disfcn.html

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understand the concept of general interactions in thermodynamics and first law of thermodynamics.

2. Demonstrate knowledge of general interactions in thermodynamics, first law in thermodynamics, Helmholtz free energy, Gibb's free energy & Clausius-Clapeyron equation, vapor-pressure curve.
3. Understand the concepts of thermal interactions and the zeroth law of thermodynamics.
4. Study systems in thermal contact with a heat reservoir, canonical distribution, and energy fluctuations.
5. Calculate the entropy of a system in a heat bath and analyze the Helmholtz free energy. Explore adiabatic interactions, enthalpy, and the first law of thermodynamics.
6. Study infinitesimal general interactions and Gibb's free energy.
7. Explore phase transitions, including first and second-order phase transitions. Understand the Clausius-Clapeyron equation and the vapor pressure curve.
8. Analyze the transformation of disorder into order and the efficiency of heat engines, including Carnot's cycle.
9. Learn about the thermodynamic scale as an absolute scale and apply Maxwell relations.
10. Derive Maxwell's law of distribution of velocities and verify it experimentally. Calculate the most probable, average, and root mean square velocities.
11. Study diffusion and the equipartition theorem. Explore the classical theory of specific heat capacity and analyze the specific heat of solids.
12. Understand transport phenomena, including mean free path, coefficients of viscosity, thermal conductivity, and diffusion.
13. Applications of Clausius-Clapeyron equation, first & second law of thermodynamics.
14. Explain the concept of Carnot's engine and applications, Maxwell equations and their applications.
15. Explain the principle of low temperature production, Joule-Thomson expansion and porous plug experiment.
16. Explain the concept of regenerative cooling and applications by adiabatic cooling & colling by demagnetization.
17. Applications of low temperature production, He I & He II, superfluidity.
18. Applications of superfluidity in superconductors, Meisner effect.
19. Study the production of low temperatures and cooling by adiabatic expansion. Analyze the coefficient of performance, Joule-Thomson effect, J-T coefficient, and temperature of inversion.
20. Learn about the quest for absolute zero and the third law of thermodynamics.
21. Understand the concept of kinetic theory of gases, energy distribution function & Maxwell's equations.
22. Experimental verification of Maxwell velocity distribution & principle of equipartition of energy.
23. Explain the transport phenomenon of gases, mean free path, distribution of mean paths, viscosity & diffusion.
24. Explanation of thermodynamics in the framework of statistical approach.
25. Formulation of classical statistics to form phase space, micro- and macro-spaces, thermodynamic probability, monoatomic ideal gas & heat capacity of solids. Understand classical statistics and its validity. Study phase space, microstates, macrostates, thermodynamic probability, and entropy.
26. Formulation of quantum statistics & explanations.
27. Postulates of quantum statistics, wavefunction, exchange degeneracy, Bose-Einstein & Fermi-Dirac statistics, Planck distribution function.
28. Learn about quantum statistics, including Bose-Einstein and Fermi-Dirac distribution laws. Calculate the thermodynamic functions of weakly and strongly degenerate gases.
29. Analyze the behavior of an ideal Bose gas and derive Planck's law.
30. Study the flux of radiation energy, radiation pressure, and the thermodynamic functions of an ideal Fermi electron gas.
31. Understand the free electron model for metals, the spectrum of metals, Richardson's equation of thermionic emission, relativistic Fermi gas, and the Chandrasekhar mass limit for white dwarf stars.
32. Understand the concepts of contact potential & thermionic emission, nuclear spin-states.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - II

Physics Practical Lab (II)

(DSCP HPHY 211, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
II	DSCP HPHY 211	Physics Practical Lab (II)	5	04
Level of Course	Core	Delivery Type of The Course		
Introductory	Core	Practical, One Hundred and Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the Physics Practical Lab (II), with the mentioned experiments, is to provide students with hands-on experience in conducting experiments related to electricity & magnetism. The lab aims to reinforce theoretical concepts learned in the classroom, develop practical skills, and enhance the understanding of physics principles through experimentation.			

DSCP HPHY 211 : Physics Practical Lab (II)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis. Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - II

1. To study the random decay and determine the decay constant using the statistical board.
2. Using compound pendulum study the variation of time period with amplitude in large angle oscillations.
3. To determine Young's modulus by bending of rectangular cross-sectional beam.
4. To determine Young's modulus (Y), σ (Poisson's ratio) and η (modulus of rigidity) by Searle's method.

5. To determine the modulus of rigidity of a wire using Maxwell's needle.
6. To determine the Poisson's ratio of a rubber tube.
7. To study the magnetic field along the axis of a current carrying circular coil, drawing the necessary curve and hence find the radius of the circular coil.
8. To study damping using a compound pendulum/bar pendulum and determine damping coefficient & quality factor of the compound pendulum.
9. To study radius of gyration and to determine acceleration due to gravity (*g*) using a compound pendulum/bar pendulum.
10. To study the variation of surface tension with temperature using Jaeger's method.
11. To study the sensitivity of a cathode ray oscilloscope (CRO).
12. To convert a given voltmeter to an ammeter of suitable range and calibrate the ammeter.
13. To convert a given ammeter (μA to mA) to a voltmeter of suitable range and calibrate the voltmeter.
14. To determine the moment of inertia of a fly-wheel.
15. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes :

Through these experiments, students will develop practical skills in experimental techniques, data collection, analysis, and interpretation. They will also enhance their understanding of fundamental concepts and principles in oscillations, damping, coupled oscillators, and material properties. The lab experiences will foster critical thinking, problem-solving abilities, and the application of theoretical knowledge to real-world scenarios.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - III

Paper (V) - Optics

(DSC HPHY 301, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. **(7 x 2 marks each = 14 marks)**

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. **(4 x 14 marks each = 56 marks)**

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
III	DSC HPHY 301	Optics	6	4
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	Core	**Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of optics. It aims to develop their knowledge and skills in analysing basic phenomenon of interference, far- and near-field diffraction phenomena, polarization phenomenon, quantum optics and applications, as well as basics of lasers and holographic applications.			

Unit - I : Coherence, Interference & Interferometers

Concept of spatial and temporal coherence, Coherence length, Coherence time, Definition and propagation of wavefront, Huygen's principle of secondary wavelets, Young's double slit experiment, Types of fringes, Interference by division of wavefront : Fresnel's bi-prism, Measurement of wavelength and thickness of a thin transparent sheet, Interference by division of amplitude – Thin films (parallel and wedge-shaped films), Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes), Newton's rings : Measurement of wavelength and refractive index, Michelson's Interferometer, Shape of fringes, Measurement of wavelength, Difference between two spectral lines and the thickness of a thin transparent sheet. Theory of Fabry-Perot interferometer, visibility & shape of fringes. **(15 Lectures)**

Unit - II : Zone Plate, Diffraction & Grating

Zone Plate : The basic theory of Zone plate, Half-period zones, Zone plate, Multiple Foci of zone plate, Comparison between zone plate and convex lens.

Fraunhofer Diffraction : Single slit, Double slit, Multiple slits, Missing orders, Fraunhofer diffraction by a circular aperture, Fraunhofer diffraction by two parallel slits.

Fresnel's Diffraction : Fresnel's diffraction by a circular aperture, straight edge, and a rectangular slit, Cornu's spiral geometrical method to study Fresnel's diffraction pattern.

Grating : Plane diffraction grating, Transmission and reflection gratings, Concave grating, Rowland's mounting, Dispersion by a grating, Rayleigh's criterion of resolution, Resolving power of a grating, resolving power of a telescope. **(15 Lectures)**

Unit - III : Polarization & Double Refraction

Polarization : Polarization (i) Plane polarized light (ii) Circularly polarized light (iii) Elliptically polarized light, Production of plane-polarized light (i) by reflection (ii) by refraction (iii) by double refraction, and (iv) by dichroism (Polaroid), Brewster's law, Law of Malus.

Double Refraction : Huygens' wave theory of double refraction, Analysis of polarized light : Nicol prism, Quarter wave plate and half-wave plate, Optical activity, Laws of optical activity, Fresnel's explanation of optical activity, Specific rotation, Polarimeters : Laurent's half shade polarimeter and Biquartz polarimeter. **(15 Lectures)**

Unit - IV : LASER, Holography & Fiber Optics

LASER : Spontaneous and stimulated emission, Einstein's A and B coefficients, Relations among Einstein's coefficients, Condition for stimulated emission and absorption, Population inversion, Methods of optical pumping, Energy level scheme of He-Ne & Ruby lasers, Semiconductor laser, Working principle of Ruby, He-Ne, CO_2 and semiconductor laser, Tunnel lasers (qualitative discussion only).

Holography : Basic concept of holography, Difference between a hologram and a photograph, Construction of a hologram and reconstruction of the image, Applications of holography.

Fiber Optics : Introduction to optical fiber, Types of optical fiber, Total internal reflection, Explanation of propagation of light through an optical fiber. **(15 Lectures)**

Savita

Reference Books/Text Books

1. Optics by Brijlal and Subramanium, S. Chand Publishing.
2. Principles of Optics by B.K. Mathur, Gopala Printing.
3. Optics by D. P. Khandelwal, Himalaya Publishing House.
4. Introduction to Modern Optics by A. K. Ghatak, McGraw Hill.
5. An Introduction To Modern Optics by G. R. Fowels, Dover Publications.
6. Fundamentals of Optics by Ashok Kumar, D. R. Gulati & H. R. Gulati, R. Chand & Co.
7. Optical Physics South Asian Edition by A. Lipson, S. G. Lipson & H. Lipson, Cambridge University Press.
8. E. Hecht & A. R. Ganesan, Optics 5th Ed., Pearson Publications.
9. Devraj Singh, Fundamental of Optics, PHI Publications.

Suggested E-Resources :

1. MIT OpenCourseWare : Optics - This resource offers lecture notes, assignments, and exams for a complete course on optics : https://ocw.mit.edu/search/?q=optics
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in optics : http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
3. NPTEL Course : https://onlinecourses.nptel.ac.in/noc25_ph53/preview

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understand the concept of interference and diffraction fields and their physical significance.
2. Demonstrate knowledge of interference, diffraction, and polarization.
3. Applications of interference, and diffraction in framework of Fraunhoffer & Fresnel diffraction phenomenon.
4. Explain the formation of Newton's rings and determination of wavelength & refractive index.
5. Explain the principle of Michelson's interferometer and determination of wavelength & refractive index.
6. Explain the concept of polarization in optics.
7. Production and analysis of different type of polarizations and their applications.
8. Explain the concept of quantum optics.
9. Explain the concept of laser, holography & fiber optics.
10. Solve problems related to above mentioned topics.

Savita

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - III

Paper (VI) – Mathematical Physics

(DSC HPHY 302, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note : There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. **(7 x 2 marks each = 14 marks)**

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. **(4 x 14 marks each = 56 marks)**

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
III	DSC HPHY 302	Mathematical Physics	6	4
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of mathematical problems in physics framework. It aims to develop their knowledge and skills in analyzing the basic concepts of mathematics, vectors & vector spaces, orthogonal curvilinear coordinate system, Fourier series, matrices, solutions of differential equations, Bessel functions, solution of partial differentiation by separation of variable technique and its application to the boundary value problems.			

Unit – I : Orthogonal Curvilinear Coordinate System & Coordinate Transformation

Coordinate Systems : Orthogonal curvilinear coordinate system, Scale factors, Expression for Gradient, Divergence & Curl and their applications to cartesian, circular, cylindrical and spherical polar coordinate systems, Coordinate transformation and Jacobian. **(15 Lectures)**

Unit - II : Tensors & Fourier's Theorem

Tensors : Transformation of covariant, Contravariant & mixed tensors, Addition, multiplication & contraction of tensors, Metric tensor and its use in transformation of tensors, Dirac delta function and its properties.

Fourier's Theorem : Fourier's theorem and computation of Fourier coefficient, Even and odd functions, Half range expansion, Sums & scale changes, Forced oscillations, Expansion Techniques : Integration & Differentiation, Introduction to Fourier transform and its simple applications. **(15 Lectures)**

Unit - III : Differential Equations, Bessel & Legendre's Functions

Differential Equations : Solution of differential equations-Series method : Properties of power series, Solution of ordinary differential equation : Legendre's Equation, Legendre polynomials & functions, Hermite polynomials, Method of Frobenius : Solution about regular singular points, Gamma function, Bessel-Clifford equation, Roots differing by an integer : Series method, Solution of Bessel equation for : (i) roots not differing by an integer (ii) equal roots (iii) roots differing by an integer.

Bessel & Legendre's Functions : Basic identities involving Bessel Functions, Basic properties like orthogonality recurrence relation and generating functions of Bessel, Hermite, Legendre, and associated Legendre's function (simple applications). **(15 Lectures)**

Unit - IV : Partial Differential Equations (PDEs) & Applications To Boundary Value Problems

PDEs : Solution of partial differential equation by separation of variable technique and its application to following boundary value problems : (i) Laplace equation in three-dimensional cartesian coordinate system - Line charge between two earthed parallel plates, (ii) Laplace equation in spherical coordinate system - Electric potential about a spherical surface, (iii) Wave equation in two-dimensional cartesian coordinate system - Heat conduction in a thin rectangular plate and (iv) Diffusion equation in cylindrical coordinate system. **(15 Lectures)**

Reference Books

1. Mathematical Methods by Potter and Goldberg, Prentice Hall of India Pvt. Ltd.
2. Applied Mathematics for Engineers and Physicists by Pipes and Harvili, Tata McGraw Hill Book Co.
3. Mathematical Methods for Physicists : G. B. Arfken and H. J. Weber, Harcourt Academic Press.
4. Mathematical Physics : A. K. Ghatak, L. C. Goyal and S. J. Chua, Laxmi Publications Pvt. Ltd.
5. Mathematical Physics : P. K. Chattopadhyay, New Age International Publishers.

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Suggested E-Resources :

1. Swayam NPTEL : Mathematical Physics - This resource offers lecture notes, assignments, and exams for a complete course on optics : https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ph01
2. NPTEL - This online resource provides concise explanations and interactive simulations for various topics in mathematical physics : https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_ma48

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understand the concept of orthogonal curvilinear coordinate system.
2. Understanding applications of gradient, divergence and curl to cartesian, circular, cylindrical and spherical polar coordinate systems.
3. Understand the concept of coordinate transformation & Jacobian.
4. Understand the concept of Fourier series & matrices.
5. Understand the solution of differential equations by various techniques.
6. Understand the concept of Bessel functions.
7. Understand the concept of partial differential equations by separation of variable technique.
8. Understanding of the application of partial differential equations to boundary value problems.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - III

Physics Practical Lab (III)

(DSCP HPHY 311, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)
Note: Out of the following experiments, 8 experiments must be done by the students in the semester.

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
III	DSCP HPHY 311	Physics Practical Lab (III)	6	04
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Practical, One Hundred & Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the physics lab with the mentioned experiments, is to provide students with hands-on experience in conducting experiments related to optics, thermodynamics and mechanics. Optics experiments include formation of Newton's rings, use of Michelson's Interferometer, experiments related to prism, grating, biprism, specific rotation of sugar solution. Thermodynamics experiments include Desorme's method & Lee's apparatus. Electrical experiments include determination of bandgap of a semiconductor & ballistic galvanometer. The lab aims to reinforce theoretical concepts learned in the classroom, develop practical skills, and enhance the understanding of physics principles through experimentation.			

DSCP PHY 311 : Physics Practical Lab (III)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis.

Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - III

1. To determine the thermodynamic constant $\gamma = C_P/C_V$ using Clements & Desorme's method.
2. To determine the thermal conductivity of a poor thermal conductor by Lee's method.
3. To study the specific rotation of sugar solution by polarimeter.
4. To determine the bandgap of a given semiconductor using a junction diode.
5. Using platinum resistance thermometers find the melting point of a given substance.
6. Using Newton's rings method find out the wavelength of a monochromatic source.
7. To determine the ballistic constant of a ballistic galvanometer (BG).
8. To determine the high resistance by leakage method using ballistic galvanometer (BG) and condenser.
9. To determine wavelength of light by grating element using a spectrometer.
10. To determine the dispersive power of a grating element using spectrometer.
11. Using Newton's rings method find out the refractive index of a given liquid.
12. To determine dispersive power of prism using spectrometer.
13. To study variation of gain with frequency using a single-stage transistor audio amplifier.
14. To verify Lenz's law and study conductor interaction with a bar magnet falling vertically into the hollow metallic cylinder.
15. To study modulus of rigidity of a material as a function of temperature.
16. To study the resolving power of a prism.
17. To study the resolving power of a grating.
18. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes:

Through these experiments, students will develop practical skills in experimental techniques, data collection, analysis, and interpretation. They will also enhance their understanding of fundamental concepts and principles in optics, electronics & thermodynamics. The lab experiences will foster critical thinking, problem-solving abilities, and the application of theoretical knowledge to real-world scenarios.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - IV

Paper (VII) – Elementary Quantum Mechanics

(DSC HPHY 401, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
IV	DSC HPHY 401	Elementary Quantum Mechanics	6	4
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of elementary quantum mechanics. It aims to develop their knowledge in the evolution of quantum physics, uncertainty principle, and skills in analysis using operators. It provides students with the knowledge about Schrödinger's equation in time-dependent & time-independent domains, and solutions of Schrödinger's equation in special cases. It prepares students by equipping them with the quantum-mechanical description of H-atom & Stern-Gerlach experiment for providing detailed information about the electronic spin. Molecular spectroscopy is also explained in the regime of quantum mechanics. The objective of the course is to provide students with a comprehensive understanding of quantum-mechanical physics in a detailed manner. The course aims to develop their knowledge and skills in analysing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.			

Unit - I : Evolution of Quantum Physics

Failures of classical mechanics to explain the black-body emission spectrum, Specific heat of solids, Planck's quanta concept & radiation law, Photoelectric effect & Einstein's explanations, Compton Effect, de-Broglie hypothesis, Diffraction & Interference experiments of particles (Davisson-Germer experiment).

Uncertainty Principle : Position and momentum, Angle & angular moment, Energy and time, Application of uncertainty principle : (i) Ground state energy of hydrogen atom, (ii) Ground state energy of simple harmonic oscillator, (iii) Natural width of spectral lines, (iv) Non- existence of electron in nucleus.

Operators : Linear operators, Product of two operators, Commuting & non-commuting operators, Simultaneous eigenfunction & eigenvalues, Orthogonal wave functions, Hermitian operators & their eigenvalues, Hermitian adjoint operators, Eigenvalues & eigenfunction, Expectation values of operators : Position, momentum, energy; Ehrenfest's theorem and complementarity, Concept of group and phase velocity, Wave packet, Gaussian wave packet. **(15 Lectures)**

Unit - II : Schrödinger's Wave Equation And Its Solutions

Schrödinger's Wave Equation : General equation of wave propagation, Propagation of matter waves, Time-dependent & time-independent Schrödinger's equation, Wavefunction representation (ψ), Physical meaning of ψ, Properties and conditions on ψ, Postulates of wave mechanics, operators, observable and measurements; Probability current density.

Time independent Schrödinger's equation, Stationary state solution, One dimensional problem : Particle in one dimensional box, Eigenfunctions & eigenvalues, Discrete levels, Generalization into three dimensions & degeneracy of energy levels, Concept of a potential well and barrier, Step potential, Penetration through rectangular barrier, Reflection and transmission coefficients, Barriers with special shapes (graphical representation), Quantum mechanical tunneling effect (alpha decay). **(15 Lectures)**

Unit - III : Solutions of Schrödingers' Equation In Special Cases

Symmetric square well potential, Reflection and transmission coefficients, Resonant scattering, Bound state problems : Particle in one dimensional infinite potential well & finite depth potential well, Energy eigenvalues & eigenfunctions, Transcendental equation and its solution; Simple harmonic oscillator, Schrödinger's equation for simple harmonic oscillator and its solution, Eigenfunction & eigenvalues, Zero point energy, Quantum and classical probability density, Parity, Symmetric and antisymmetric wave functions with graphical representation.

Schrödinger's equation in spherical coordinates, Schrödinger's equation for one electron atom in spherical coordinates, Separation into radial and angular variables, Solution of the radial equation & angular equation, Qualitative discussion of spherical harmonics, Series solution, and Energy eigenvalues, Stationary state wave function, Wave-functions of H-atom for the ground and first excited states, Average radius of H-atom, Bohr's correspondence principle, Orbital angular momentum and its quantization, Commutation relation, Eigenvalues and eigenfunctions.

(15 Lectures)

Unit - IV : H-Atom, Atomic & Molecular spectroscopy

H-atom : Energy level derivation for H-atom, Quantum features of hydrogen spectra & hydrogen-like spectra, Stern-Gerlach experiment, Electron spin, Spin magnetic moment, Spin-orbit coupling, Qualitative explanation of fine structure, Franck-Hertz experiment, Zeeman effect, Normal Zeeman splitting.

Representations, Transformations & Symmetries : Quantum States; State vectors & Wavefunctions, Hilbert space of state vectors; Dirac notation-(a) State vectors and their conjugates (b) Norm & Scalar Product (c) Basis in Hilbert space, Dynamical variables & linear operators-(a) Abstract operators; Quantum Conditions (b) The Adjoint; Self-Adjointness (c) Eigen values & Eigen Vectors (d) Expansion of the identity; Projection operators (e) Unitary operators, Representations-(a) Representation of state vectors : The Wave function (b) Dynamical variables as matrix operators (c) Products of operators : The Quantum Condition (d) Self-Adjointness and Hermiticity.

(15 Lectures)

Reference Books/Text Books

1. Griffiths, Introduction to Quantum Mechanics, 2nd edition by Pearson.
2. R. Shankar, Principles of Quantum Mechanics, 2nd edition.
3. Arthur Beiser, Perspective of modern Physics, 6th edition.
4. A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and application, Trinity Press.
5. H. S. Mani, G. K. Mehta, Introduction to Modern Physics, Affilated East And West Publishers.
6. C. N. Banwell & E.M. McCash, Fundamental of Molecular Spectroscopy, McGraw-Hill Publishers.
7. H. E. White, Introduction To Atomic Physics, McGraw-Hill Publishers.
8. P.M. Mathews and K. Venkatesan-A Textbook of Quantum Mechanics, McGraw Hill Education India.

Suggested E-Resources :

1. MIT OpenCourseWare : Quantum Mechanics - This resource provides lecture notes, problem sets, and solutions for a complete course on quantum mechanics : https://ocw.mit.edu/search/?q=quantum%20mechanics
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in quantum physics : http://hyperphysics.phy-astr.gsu.edu/hbase/quacon.html#quacon
3. NPTEL UG Course : https://onlinecourses.nptel.ac.in/noc24_ph15/preview
4. Lecture Series on Quantum Physics by Prof. V. Balakrishnan, Department of Physics, IIT Madras.

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understanding of the evolution of quantum mechanics.
2. Understanding of the uncertainty principle.
3. Understanding of the operators in quantum mechanics.
4. Understanding of the Schrödinger wave equation.

5. Understanding of the time-dependent & time-independent Schrödinger's equation and their solutions.
6. Understanding of the solutions of Schrödinger's equation in special cases.
7. Understanding of the quantum harmonic oscillator.
8. Understanding of quantum-mechanics of hydrogen atom.
9. Understanding of molecular spectroscopy in terms of quantum mechanics.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - IV

Paper (VIII) – Electronics And Solid-State Devices

(DSC HPHY 402, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. **(7 x 2 marks each = 14 marks)**

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. **(4 x 14 marks each = 56 marks)**

Semester	**Code of The Course**	**Title of The Course/Paper**	**NHEQF Level**	**Credits**
IV	**DSC HPHY 402**	**Electronics & Solid-State Devices**	**6**	**4**
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the course is to provide students with a comprehensive understanding of the fundamental concepts and principles of electronics & semiconductor device physics. It aims to develop their knowledge and skills in analysing PN junctions, bipolar junction transistors (BJTs), field effect transistors (FETs), digital circuits, diode-transistor logic (DTL), transistor-transistor logic (TTL), amplifiers, operational amplifiers, oscillators & feedback circuit mechanisms. The course aims to develop their knowledge and skills in analysing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.			

Unit - I : Diode And Transistors

PN Junction : Charge densities in N and P materials; Conduction by drift & diffusion of charge carriers; PN diode equation; Capacitance effects.

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Transistor Fundamentals : Notations and volt-ampere characteristics for bipolar junction transistors (BJTs); Concept of load line & operating point, Hybrid parameters, Configurations : Common Base (CB), Common Emitter (CE), Common Collector (CC).

Transistor Biasing : Need for biasing & stability of Q point, Stability factor, Types of bias circuits for thermal bias stability : Fixed bias, Collector-to-base feedback bias & Four-resistor bias.

(15 Lectures)

Unit - II : FET & Logic Operations

Field Effect Transistors (FETs) : Introduction to FET and its merits/demerits, Junction Field Effect Transistor (JFET), Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET), Circuit symbols, Biasing & Volt-ampere characteristics.

Boolean Algebra & Logic Operations : Fundamentals of Boolean algebra, Boolean variables & functions, De Morgan's theorem, Basic logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR), Symbols, Truth tables, Boolean expressions, Diode-Transistor Logic (DTL) concept and configuration, Transistor-Transistor Logic (TTL) concept and evolution from DTL. **(15 Lectures)**

Unit - III : Amplifiers and Oscillators

Amplifiers : Analysis of transistor amplifiers using hybrid parameters, Gain-frequency response, Basic ideas of direct-coupled (DC) & RC coupled amplifiers, Differential amplifiers.

Amplifiers With Feedback : Concept of feedback, Positive & negative feedback, Voltage & current feedback circuits, Advantages of negative feedback : Stabilization of gain, Effect on output & input resistance, Reduction of nonlinear distortion, Effect on gain-frequency response.

Oscillators : Criteria for self-excited & self-sustained oscillations, Circuit requirements for the build-up of oscillations, Basic transistor oscillator circuit and its analysis, Colpitt's oscillator, Hartley oscillator & RC oscillator. **(15 Lectures)**

Unit - IV : Introduction To Operational Amplifier

Operational Amplifiers : Definition and history, Importance and applications in electronic circuits, Basic building blocks and components, Ideal vs. Real Op-Amps : Infinite gain, Infinite input impedance, Zero output impedance, etc.

Practical Op-Amp Limitations : Bandwidth, Slew rate, Offset voltage, Bias currents & noise, Key parameters : Input offset voltage & current, Common-mode rejection ratio (CMRR), Input & output impedance, Open-loop gain & frequency response.

Basic Op-Amp Configurations : Inverting amplifier, Non-inverting amplifier, Voltage follower (Buffer) circuit.

Advanced Op-Amp Circuits: Summing amplifier, Differential amplifier, Integrator & differentiator, Frequency response & stability. **(15 Lectures)**

Reference/Textbooks:

1. Basic Electronics and Linear Circuits by N.N. Bhargava, D.C. Kulshreshtha; S.C. Gupta, McGraw Hill.
2. Electronic Devices and Circuits by J.B. Gupta, Katson Educational Series.
3. Solid State Electronic Devices by Ben G. Streetman & Sanjay Kumar Banerjee, Pearson Education India.
4. Integrated Electronics : Analogue and Digital Circuits by Milman & Halkias, McGraw Hill Education.
5. Semiconductor Physics and Devices" by Donald A. Neamen, McGraw Hill.
6. Electronic Principles by Albert Malvino and David J. Bates, SIE, McGraw Hill Education.
7. Digital Principles and Applications by Donald P. Leach, Albert Paul Malvino, and Goutam Saha, McGraw Hill.

Suggested E-Resources :

1. MIT OpenCourseWare : Electronics & Solid State Devices - This resource provides lecture notes, problem sets, and solutions for a complete course on electronics & solid state devices : https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in electronics : http://hyperphysics.phy-astr.gsu.edu/hbase/Electronic/etroncon.html
3. NPTEL UG Course : https://nptel.ac.in/courses/108106181

Course Learning Outcomes :

By the end of the course, students should be able to :

1. Basic understanding of concept of oscillators.
2. Concept and electronics of different types of oscillators of Colpitts and Hartley oscillators, RC oscillators.
3. Basic understanding of operational amplifiers & characteristics.
4. Concept of feedback and feedback amplifiers, effect on frequency gain response.
5. Introduction to field effect transistors (FETs), JFETs, metal-oxide-semiconductor field effect transistors (MOSFET) and voltage-current responses.
6. Learning of digital circuits and related theories.

Saeita

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - IV

Physics Practical Lab (IV)

(DSCP HPHY 411, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)
Note: Out of the following experiments, 8 experiments must be done by the students in the semester.

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
IV	DSCP HPHY 411	Physics Practical Lab (IV)	6	4
Level of Course	**Type of The Course**	**Delivery Type of The Course**		
Introductory	**Core**	**Practical, One Hundred & Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.**		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of the physics lab-IV, with the mentioned experiments, is to provide students with hands-on experience in conducting experiments related to electronics. The lab aims to reinforce theoretical concepts learned in the classroom, develop practical skills, and enhance the understanding of physics principles through experimentation. Different experiments related to digital electronics, rectifiers, Anderson's bridge & De Sauty's bridge and transistors will be performed to provide the glimpse of real-time semiconductor applications to the students.			

DSCP HPHY 411 : Physics Practical Lab (IV)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis.

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Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - IV

1. To construct a half-wave rectifier using single diode and analysis of ripple factor and efficiency.
2. To construct full wave/bridge rectifiers and analysis of ripple factor and efficiency.
3. To study characteristics of a given transistor PNP (common emitter, common base and common collector configurations).
4. To study characteristics of a given transistor NPN (common emitter, common base and common collector configurations).
5. To study analog to digital (A to D) conversion in digital electronics
6. To study digital to analog (D to A) conversion in digital electronics.
7. To measure the inductance of a coil by Anderson's bridge.
8. To study the working of a De Sauty's bridge & to compare the capacitances of two capacitors.
9. To determine the speed of sound in air by standing wave method using speaker, signal generator, microphone & CRO (2-beam oscilloscope).
10. To determine the wavelength of a hollow prism.
11. To determine the refractive index of a hollow prism.
12. Using Michelson's interferometer find out the wavelength of given monochromatic source of light (Sodium light).
13. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes:

Through these experiments, students will develop practical skills in experimental techniques, data collection, analysis, and interpretation. They will also enhance their understanding of fundamental concepts and principles in electronics. The lab experiences will foster critical thinking, problem-solving abilities, and the application of theoretical knowledge to real-world scenarios.

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Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - V

Paper (IX) – Introductory Nuclear & Particle Physics

(DSC HPHY 501, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. **(7 x 2 marks each = 14 marks)**

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. **(4 x 14 marks each = 56 marks)**

<table>
<tr><th>Semester</th><th>Code of The Course</th><th>Title of The Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>V</td><td>DSC HPHY 501</td><td>Introductory Nuclear & Particle Physics</td><td>7</td><td>4</td></tr>
<tr><td>Level of Course</td><td>Type of The Course</td><td colspan="3">Delivery Type of The Course</td></tr>
<tr><td>Introductory</td><td>Core</td><td colspan="3">Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.</td></tr>
<tr><td>Prerequisites</td><td colspan="4">Physics and Mathematics courses of Central Board of Secondary Education or equivalent.</td></tr>
<tr><td>Objectives of The Course :</td><td colspan="4">The objective of this course is to provide students with a comprehensive understanding of nuclear physics. The course aims to develop a strong foundation in the principles and concepts of nuclear physics, and their applications in describing the nucleus and nuclear interactions along with particle physics. The course aims to focus on the properties of the properties of the nucleus, nuclear forces, various nuclear models, radioactive decays, nuclear fission and fusion, nuclear reactions, the interaction of heavy charged particles and gamma rays with matter, radiation detectors, elementary particles, and particle accelerators.</td></tr>
</table>

Unit - I : Basic Nuclear Characteristics & Nuclear Forces

Basic Properties of Nucleus : Nuclear mass, Nuclear size & nuclear matter, Mass table, Binding energy of nucleons, Semiempirical mass formula, Nuclear matter characteristics, Theory of binding energy & pairing energy, Nuclear stability & abundance of nuclides, Spin & parity of nuclear states, Magnetic dipole & electric quadrupole moments of nucleus.

Nuclear Forces : General nature of force between nucleons : Yukawa Meson theory, Nuclear potential, Scattering of neutrons by protons at low energy, Two nucleons system, Deuteron magnetic dipole & electric quadruple moments, Non-central forces, p-p & n-n scattering at low energy, Charge independence of nuclear forces & concept of iso-spin invariance. **(15 Lectures)**

Unit - II : Nuclear Models, Fission, Fusion & Interactions

Nuclear Models : Empirical evidence for the regularity of nuclear properties : Nuclear mass & binding energy, Magic numbers, Liquid drop model, Fermi gas model, Evidence for nuclear shell structure, Basic assumptions of the shell model, Single particle shell model, Average shell model potential.

Fission & Fusion : Discovery of fission, Theory of fission, Energy release, Criticality of a reactor & Four factor formula, Types of fuels & types of reactors, Breeder Reactor, Neutron cycle in a thermal Nuclear Reactor, Nuclear fusion, Energy released in nuclear fusion, Fusion in stars. **(15 Lectures)**

Unit - III : Nuclear Radiation Interaction, Detectors & Acceleration

Interaction of Nuclear Radiation : Passage of charged particle through matter, Energy loss by collision, Energy loss by radiative process, Range-energy curve, Range straggling, Stopping power of heavy ions, Law of absorption for gamma ray interaction, Photoelectric effect, Compton scattering, Pair-production.

Radiation Detector : Modes of operation-current mode & pulse mode, Gas filled detectors-Ionization chamber, Proportional counter, Geiger-Muller counter, Scintillator detectors - Organic and inorganic scintillation detector.

Particle Accelerators : Ion source, Van-de-Graff accelerator (Tandem Accelerator), Linear accelerator, Cyclotron, Synchrocyclotron, Betatron, Proton synchrotron. **(15 Lectures)**

Unit - IV : Introduction To Particles Physics & Conservation Laws

Introduction To Particles : Introduction to electron, Alpha particles, Photon, Positron, Neutron, Neutrino & Muons, Baryons and Leptons, Discovery of Pion and its characteristics, Deltas, Strangeness & kaons etc., Lambda and other Hyperons.

Conservation Laws : Introduction to charge conjugation, Space parity & Gellman Nishijima Scheme, Patron, Quark model - quark and gluons, Quark composition of baryons and mesons J/Y particle, W and Z-particles and Higgs, Emphasis should be given on experimental discoveries and conservation laws while introducing the particles and resonances, Introduction of SU(3) symmetry.

(15 Lectures)

Reference Books/Text Books

1. Nuclear and Particle Physics by W. E. Burcham and M Jobes, Addison-Wesley Longman Inc.
2. Nuclear and Particle Physics by Brian R Martin, John Wiley & Sons.
3. Introduction to Nuclear and Particle Physics by Das and Ferbal, World Scientific.
4. Elements of Nuclear Physics by Walter E. Meyerhof, McGraw-Hill Book Company.
5. Introductory Nuclear Physics by Kenneth S. Krane, John Wiley & Sons.
6. Introduction to Elementary Particles by David J. Griffiths, John Wiley & Sons.
7. Radiation Detection and Measurement by G.F. Knoll, John Wiley & Sons.

Suggested E-Resources :

1. MIT OpenCourseWare : Nuclear Physics - This resource offers lecture notes, assignments, and exams for a complete course on nuclear physics : https://ocw.mit.edu/courses/8-701-introduction-to-nuclear-and-particle-physics-fall-2020/
2. HyperPhysics - This online resource provides concise explanations and interactive simulations for various topics in nuclear physics : http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/nucstructcon.html
3. NPTEL : Nuclear Physics : Fundamentals & Applications : https://nptel.ac.in/courses/115104043
4. Swayam NPTEL : Nuclear & Particle Physics : https://onlinecourses.nptel.ac.in/noc20_ph19/preview

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Understanding of the various nuclear properties of nuclei; nuclear magnetic dipole moment & electric quadrupole moment.
2. Explanation of nuclear ellipticity, nuclear spin, isospin, parity, parity conservation, and orbital angular momentum.
3. Concepts of nuclear mass, nuclear energy, packing fraction.
4. Discovery of neutron, n-p hypothesis, n/p ratio, nuclear potential, mass defect, binding energy.
5. Basic understanding of theory of nuclear forces & their properties; Yukawa-Meson theory.
6. Concepts of radioactive decays, α-decay, β-decay, γ-decay in detail.
7. Basic understanding and explanation of nuclear fission, nuclear fusion & nuclear reactions.
8. Basic understanding of interaction of nuclear radiation with matter, Bremsstrahlung radiation, Cherenkov radiation, Gamma ray interaction with matter.
9. Nuclear models to explain and understand the nucleus; Liquid-drop model, Fermi gas model, Shell model.
10. Understanding of fission & fusion.
11. Understanding of nuclear radiation interactions, different types of radiation detectors & particle accelerators.
12. Understanding of different types of particles & particle physics of nucleus and conservation laws.
13. Explain the functions and types of particle accelerators, such as Van de Graaff accelerators, linear accelerators, cyclotrons, synchrocyclotrons, betatrons, and proton synchrotrons.
14. Recognize elementary particles within the Standard Model and describe their interactions and historical discovery.
15. Understand and apply symmetries and conservation laws (C, P, and T invariance) to particle reactions and processes.
16. Discuss flavor symmetries, the Gell-Mann-Nishijima formula, the eightfold way, and the role of quarks and gluons in particle physics.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - V

Paper (X) – Numerical Methods & Computer Programming

(DSC HPHY 502, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
V	DSC HPHY 501	Introductory Nuclear & Particle Physics	7	4
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of this course is to provide students with a comprehensive understanding of different concepts in numerical methods as well as Computer Programming in C languages. The course aims to develop some efficient algorithms to process and analyze complex datasets in scientific and engineering disciplines.			

Unit - I : Algorithm Development & Data Representation

Algorithm Development : Problem analysis, Flow chart, Decision tables, Examples of simple algorithms, Debugging syntax error, Run-time error, Logical error, Programme verification and testing.

Data Representation : Representation of positive & negative numbers, Fixed point representation, Floating point representation, Arithmetic operations with normalized floating-point numbers and its consequences, Character representation, Founding of numbers, Absolute & relative errors, Error detection & error correcting codes. **(15 Lectures)**

Unit - II : Programming in Language C & Conditional Statements

Programming in Language C : Numeric constants, Declaring variable names, Character data type, Arithmetic operators, Hierarchy of operations, Assignment statements, Input/output statements, Library functions, Elementary programmes in C for numeric and string processing.

Conditional Statements : Relational operators, Arithmetic IF & Logical IF statements, Unconditional transfer : GO TO statement, Looping : DO loops, Nested loops. Functions & subroutines, Subscripted variables : Vectors & arrays. **(15 Lectures)**

Unit - III : Iterative Methods

Iterative Methods : Solution of algebraic & transcendental equations using bisection method, Method of false position, Newton-Raphson method, Complex zeros, Zeros of polynomials, Interpolation : Lagrange interpolation, Difference tables, Truncation error in interpolation, Spline interpolation. **(15 Lectures)**

Unit - IV : Regression, Polynomials, Numerical Integration, Numerical Solution of Ordinary Differential Equations & Finite Difference Methods

Regression & Polynomials : Least Square Approximation, Linear regression, Polynomial regression, Fitting exponential & trigonometric functions, Approximation of functions by Taylor' series & Chebyshev polynomials, Curve fitting & polynomial fitting.

Numerical Integration : Trapezoidal rule, Simpson's rule, Errors in integration formulas, Gaussian quadrature formulae.

Numerical Solution of Ordinary Differential Equations : Predictor-Corrector method and Runge-Kutta methods; Numerical Solution of Partial Differential Equations. **(15 Lectures)**

Reference Books/Text Books

1. Computer Science, R. Dheen Dayalue (Tata Mc Graw Hill)
2. Computer System Architecture, Morris-Mano (Prentice Hall of India)
3. Computer Oriented Numerical Methods, V. Rajaraman (Prentice Hall of India)
4. Mathematical Methods, Potter and Goldberg (Prentice Hall of India)
5. Computational Methods for Partial Differential Equations, M. K. Jain, S. R. K. lyenger, R. K. Jain, (New Age International)
6. Lafore Robert, "Object-Oriented Programming in C++", Waite Group's ,4th Edition.

Suggested E-Resources

1. http://www.nptelvideos.in/2012/11/numerical-methods-and-programing.html
2. http://www.nptelvideos.in/2012/11/numerical-methods-and-computation.html
3. https://nptel.ac.in/courses/122106033/
4. https://nptel.ac.in/courses/122106033/25

Course Learning Outcomes

1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. Apply numerical methods to obtain approximate

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solutions to mathematical problems.

2. Enhancement of algorithms and solving complex equations, numerical techniques are indispensable in addressing the challenges faced by computer scientists and engineers.
3. Understand importance and applications of numerical methods.
4. Obtain a spontaneous and working understanding of numerical methods for the basic problems of numerical analysis.
5. Knowledge in the implementation of numerical methods using a computer.
6. Trace error in these methods and need to analyze and predict it.
7. Implementation of numerical methods in computer programming using C language.
8. Apply mathematics in engineering problems.
9. By this, Possibility to find the real root of many equation (which is not possible to find out the real root by simple methods).

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - V

Physics Practical Lab (V)

(DSCP HPHY 511, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)
Note: Out of the following experiments, 8 experiments must be done by the students in the semester.

<table>
<tr><th>Semester</th><th>Code of The Course</th><th>Title of The Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>V</td><td>DSCP HPHY 511</td><td>Physics Practical Lab (V)</td><td>7</td><td>4</td></tr>
<tr><td>Level of Course</td><td>Type of The Course</td><td colspan="3">Delivery Type of The Course</td></tr>
<tr><td>Introductory</td><td>Core</td><td colspan="3">Practical, One Hundred & Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.</td></tr>
<tr><td>Prerequisites</td><td colspan="4">Physics and Mathematics courses of Central Board of Secondary Education or equivalent.</td></tr>
<tr><td>Objectives of The Course :</td><td colspan="4">➤ To provide hands-on experience to learn and execution of programming.
➤ To develop practical skills in using various programmes and algorithms for the execution of different programmes.
➤ To reinforce theoretical concepts learned in the corresponding lecture course through practical applications.
➤ To enhance problem-solving and analytical skills by analyzing experimental data and interpreting results.
➤ To promote scientific inquiry, critical thinking, and the ability to design and execute various type of programmes of numerical methods.
➤ To foster teamwork and collaboration in conducting experiments and analyzing results.
➤ To develop skills for the execution of the programming to accurately measures and data recording.
➤ The objective of this course is to provide students with a comprehensive understanding of practical physics.
➤ The course aims to develop a strong foundation in the principles and concepts of practical physics in special reference to electronics, digital electronics & electrical domains.
➤ To develop practical skills in using various electrical components and instruments.
➤ To reinforce theoretical concepts learned in the corresponding lecture course through practical applications.
➤ To enhance problem-solving and analytical skills by analysing experimental data and interpreting results.</td></tr>
</table>

	➤ To promote scientific inquiry, critical thinking, and the ability to design and execute experiments. ➤ To develop skills in accurately measuring and recording experimental data.

DSCP HPHY 511 : Physics Practical Lab (V)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis. Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - V

Writing and executing programmes in C

1. To study the RC transmission line at 50 Hz of operational frequency.
2. To study the LC transmission line at (i) at a fixed frequency and (ii) at variable frequencies.
3. To study the resonance in an LCR circuit (using air core inductance and damping by a metal plate) at (i) a fixed frequency by varying capacitance (C), and (ii) by varying frequency.
4. To plot & study the characteristic curves of a junction diode & a Zener diode using breadboard elements.
5. To design a Zener regulated power supply and study the regulation with various loads.
6. To study and verify Thevenin's and Norton's theorems.
7. To study the characteristics of a field effect transistor (FET) and design/study amplifier of finite gain.
8. To study a voltage multiplier circuit to generate high voltage DC from AC.
9. Using discrete components, study OR, AND, NOT logic gates and to compare with TTL integrated circuits (ICs).
10. To study the frequency response of a transistor amplifier (BJT) and obtain the input & output impedance of the transistor amplifier.
11. Characteristics of operational amplifier (OP-AMP) as : (i) Non-inverting and (ii) Inverting amplifier circuits.
12. Characteristics of operational amplifier (OP-AMP) as unity buffer.
13. Characteristics of operational amplifier (OP-AMP) as : (i) adder & (ii) subtractor.
14. Applications of operational amplifier (OP-AMP) as : (i) integrator & (ii) differentiator.
15. Using discrete components, study OR, AND, NOT logic gates and to compare with DTL integrated circuits (ICs).
16. Magnetic Field of a Current-Carrying Coil : Develop a C program to calculate the

magnetic field at a given point in space due to a current flowing through a coil with specified geometry (e.g., circular, rectangular) and dimensions.

17. Electric Field of Point Charges : Design a C program to compute the electric field at a specific location due to a system of point charges with known positions and magnitudes.
18. LCR Circuit Frequency Response : Write a C program to analyze the frequency response of a circuit containing resistors (L), capacitors (C), and inductors (R) by calculating quantities like impedance and phase shift across a range of frequencies.
19. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes:

Through these experiments, students will develop practical skills in experimental techniques, data collection, analysis, and interpretation. They will also enhance their understanding of fundamental concepts and principles in electronics. The lab experiences will foster critical thinking, problem-solving abilities, and the application of theoretical knowledge to real-world scenarios.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - VI

Paper (XI) - Physics of Materials

(DSC HPHY 601, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
V	DSC HPHY 601	Physics of Materials	7	4
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of this course is to provide students with a comprehensive understanding of materials physics. The course aims to develop a strong foundation in the principles and concepts of materials related properties, synthesis techniques, and their characterization. The objective of this course is to provide students with a comprehensive understanding related to materials modification processes, defects in them and their effects, applications and various energy resources. The course aims to develop a strong foundation in the principles and concepts of materials, applications, and energy resources.			

Unit - I : Materials Science & Engineering

Introduction : Materials Science & Engineering, Classification of engineering materials, Levels of structure, Structure-property relationships in materials.

Crystal Geometry & Structure Determination : Space lattices, Space lattices & crystal structures, Crystal directions & planes, Miller Indices, Bragg's law of X-ray diffraction, Powder X-ray diffraction, Structure determination, Extinction rules for cubic crystals. **(15 Lectures)**

Unit - II : Chemical Bonding & Structure of Solids

Chemical Bonding in Solids : Bond energy, Bond type & bond length, Ionic bonding, Calculation of lattice energy of ionic crystals, Madelung constant, Covalent bonding, Metallic bonding, Secondary bonding, Variation in bonding character and properties.

Structure of Solids : Crystalline & non-crystalline states, Discussion of solidification & crystallization, Glass transition. **(15 Lectures)**

Unit - III : Band Theory of Solids & Optical Properties of Materials

Band Theory of Solids : Formation of bands (qualitative discussion), Electrons in a period field of a crystal (Kronig-Penney Model), Brillouin zones, number of states in a band, Bloch Theorem & Bloch function, Dispersion relation inside a band, Band shapes, Effective mass of an electron, Distinction between metals, insulators & intrinsic semiconductors.

Optical Properties of Materials : Introduction, Classification of Optical Materials, Interaction of light with matter, Absorption in Metals, Insulators and Semiconductors, Reflection, Refraction, Transmission and Scattering, Traps, Excitons, Colour Centers, Tauc and Lambert Beer laws, Optical properties of Photonic material. **(15 Lectures)**

Unit - IV : Dielectric Properties, Phase Diagram & Polymers

Dielectric Properties : Polarization, Temperature and frequency effect, Electric break down, Classical theory of electronic polarizability, Normal & anomalous dispersion, Complex dielectric constant & loss, Ferroelectric materials, Measurement of dielectric constant & loss, P-E hysteresis loop in ferroelectricity, Qualitative discussion of pyroelectric and piezoelectricity.

Phase Diagrams : Phase diagram, Phase rule, Single component system, Binary phase diagram, Microstructure changes during cooling, Lever rule, Phase diagram rules, Applications of phase diagram.

Polymers : Classification of polymers, Structure of long chain polymers, Crystallinity of long chain polymers. **(15 Lectures)**

Reference Books/Text Books

1. Handbook of Science and Technology in India published in 2002.
2. Materials Science and Engineering by V.S. Raghvan, TMH.
3. Solid State Electronic Engineering Materials by S.O. Pillai, Wiley Eastern Ltd.
4. Solid state Physics by C. Kittel V. Edition, John Wiley & Sons, 5^{th} Ed., 1976.
5. Introduction to Solid by Leonid V. Azaroff, Tata McGraw Hill, Indian Edition.
6. Solid State Physics by N.W. Ashcroft and N.D. Mermin, CBS Publishing Asia Ltd.

Suggested E-Resources :

1. Coursera : Nanotechnology - This resource offers lecture notes, assignments, and exams for a complete course on materials of physics : https://www.coursera.org/learn/nanotechnology
2. Udemy - This online resource provides concise explanations and interactive simulations for various topics in nanotechnology : https://www.udemy.com/course/nanotechnology/

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Attainment of knowledge about materials, structural properties of materials, crystalline & amorphous materials, space lattice, Bravais lattice.
2. Knowledge about bonding features, bond length, calculation lattice ion energy & Madelung constant.
2. Deep knowledge of covalent bonding, metallic bonding, secondary bonding, vibrational bonding etc.
3. Understanding & working methodology of XRD, powder diffraction for structural characterization of materials.
4. Knowledge about polymers and their applications in materials science.

5. Understanding of the band theory of solids.
6. Understanding of different optical properties of materials.
7. Knowledge & understanding about the concepts of dielectric properties of materials, ferroelectric materials.
8. Understanding of phase diagrams & related concepts in context to the materials.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - VI

Paper (XII) – Atomic & Molecular Physics

(DSC HPHY 602, Credits Theory 04, Lectures 60)

Duration of EoSE : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end-semester theory paper.

Part A of the paper shall contain ten short answer questions and the candidate is required to attempt any seven questions. Each question will carry 2 marks for correct answer. (7 x 2 marks each = 14 marks)

Part B of the paper will consist of four questions with one question from each unit with internal choice. Each question will carry 14 marks. (4 x 14 marks each = 56 marks)

Semester	Code of The Course	Title of The Course/Paper	NHEQF Level	Credits
VI	DSC HPHY 602	Physics of Materials	7	4
Level of Course	Type of The Course	Delivery Type of The Course		
Introductory	Core	Lecture, Sixty Lectures including diagnostic and formative assessments during lecture hours.		
Prerequisites	Physics and Mathematics courses of Central Board of Secondary Education or equivalent.			
Objectives of The Course :	The objective of this course is to provide students with a comprehensive understanding of atomic & molecular level physics. The course aims to develop a strong foundation in the principles and concepts of atomic & molecular level physics, and their applications in describing the physical theories. The course aims to develop a strong foundation in the principles and concepts of related quantum mechanical framework, magnetic field effects and spectroscopy, study of diatomic & triatomic molecules, and various experimental techniques for material characterizations with their concepts.			

Unit - I : Monovalent & Divalent Spectra

Background of Quantum Theory : Four quantum numbers, Vector model, *s*, *p*, *d*, *f* notation, Spectral terms arising from L-S & J-J coupling, Emission & absorption probabilities, Half- life of exited states, Ideal spectral line, Width of spectral lines : Natural & Doppler width.

Mono/Divalent Spectrum : Spectra of mono-valent atoms (hydrogen and like atoms), Doublet fine structure hydrogen lines, Screening constant for mono-valent atoms, Series limits, Isotopic effect, Deduction of m/M from hydrogen & deuterium spectra, Spectra of helium, Singlet & triplet series. **(15 Lectures)**

Unit - II : Magnetic Field & X-Ray spectroscopy

Effect of Magnetic field on Energy Levels : Gyromagnetic ratios for orbital and spin moments, Lande's *g* factor, Strong & weak magnetic field effects, Illustrative cases of : H, Na and Ca.

X-ray Spectra : X-ray, Generation, Continuous X-ray spectrum, Characteristics of X-ray spectrum, Duane-Hunt limit, H-like character of X-ray energy states, Moseley's Law doublet fine structure, X-ray absorption spectra, Absorption edge, Qualitative discussion of near edge & extended fine structure, Determination of atomic number of atoms. **(15 Lectures)**

Unit - III : Di-Atomic & Tri-Atomic Molecules

Molecule Formation : Sharing of electrons, Formation of molecular orbital, Qualitative discussion of H_2, N_2 and O_2 Molecule, Electronic levels & quantum numbers for electronic states of diatomic molecules : Singlet & Triplet character.

Energy Levels : Di-atomic & tri-atomic molecules, Classification & normal modes of molecules, Rotational energy levels, Inter-nuclear distance, Vibrational energy levels, Force constant, Anharmonicity, Dissociation energy, Isotopic effect on rotational & vibrational energies, Spectra of di-atomic molecules : Pure rotation spectra, Selection rules, Vibration – rotation spectra, Selection rules, P, Q, R branches, Frank-Condon principle. **(15 Lectures)**

Unit - IV : Experimental Techniques

Emission Spectroscopy : Basic block diagram of emission spectroscopy, Emission sources, Dispersive devices : Prism, Plane grating, Concave grating, Prism materials for UV, Vis & IR regions, Constant deviation systems, Monochromators, Mounting, Resolution of prism & grating, Febry-Perot & Lummer plate for high resolution.

Absorption Spectroscopy : Basic block diagram of absorption spectroscopy, Continuous source for absorption studies in X-ray, UV, Vis, and IR regions, Single beam & double beam instruments, Detection systems : Photomultiplier tube, Bolometer.

Raman spectroscopy: Raman Effect, Stoke's & anti-Stoke's lines, Raman shifts, Selection rules for Raman spectra, Selection rules for IR absorption, Structure determination of H_2O and CO_2 molecules from IR & Raman spectra, LASER as the intense source for Raman excitation. **(15 Lectures)**

Reference Books/Text Books :

1. Concepts of Modern Physics by Arthur Beiser, McGraw-Hill Book Company, 1987.
2. Atomic Physics by J. B. Rajam & Foreword by Louis De Broglie, S. Chand & Co., 2007.
3. Atomic Physics by J. H. Fewkes & John Yarwood. Vol. II, Oxford Univ. Press, 1991.
2. Physics of Atoms and Molecules by Bransden and Joachein, Pearson Education India.
3. Molecular Spectroscopy by Banwell, McGraw Hill Education.
4. Optoelectronics by Ghatak and Thyagarajan, Cambridge India.
5. Principles of Lasers by Svelto, Springer.
6. Atomic Spectra and Atomic Structure by G. Herzberg, Dover Publications Inc.

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7. Atomic Spectra by H. Kuhn, Prentice Hall Press.
8. Spectroscopy Vol, I,II, III by Walker and Straughan, Springer.
9. Introduction To Molecular Spectroscopy by H. Barrow, McGraw-Hill.
10. Introduction to Molecular Spectra by R C Johnson, Metcalf Press.
11. X-Ray Spectroscopy by B K Agarwal, Springer Series in Optical Sciences.
12. Optics and Atomic Physics by D. P. Khandelwal, Himalaya Publishing House.
13. Atomic and Molecular Physics by C. L. Arora, Campus Books International.
14. Atomic and molecular Physics by Raj Kumar, Campus Books International.

Suggested E-Resources :

1. NPTEL : Atomic & Molecular Physics - This resource offers lecture notes, assignments, and exams for a complete course on atomic & molecular physics : https://onlinecourses.nptel.ac.in/noc23_ph16/preview
2. Study.com- This online resource provides concise explanations and interactive simulations for various topics in atomic & molecular physics : https://study.com/search/text/academy.html?q=Atomic+%26+Molecular+Physics+&pageType=lesson#/topresults/Atomic%20%26%20Molecular%20Physics
3. NPTL website : http://www.digimat.in/downloads/pdf-browser/physics.pdf
4. http://sites.iiserpune.ac.in/~bhasbapat/phy420.html

Course Learning Outcomes :

By the end of the course, students should be able to:

1. Explanation of electron angular momentum and related terms.
2. Explanation of Stern-Gerlach experiment, electronic spin & spin properties.
3. Development of understanding of matter through study of atoms & molecules.
4. Understanding of basics of atomic & molecular physics.
5. Understanding of principles & processes involved in spectroscopy.
6. Description of the molecular spectra and related physics in domains of rotations & vibrations of molecules.
7. Explain the effect of magnetic fields on atoms.
8. Explanation and occurrence of Raman effect in molecules.
9. Explanation of the system of many electron atoms.
10. Explanation of lasers, related properties and mechanism of coherent light formation.
11. Explanation of semiconductor laser & He-Ne laser.
12. Understanding of basic quantum mechanics in relation to atomic and molecular physical theories.
13. Understanding of mono- and divalent atomic spectra.
14. Understanding of Hydrogen fine lines.
15. Understanding of alkali atom spectrum.
16. Understanding of atoms under magnetic field, Zeeman effect both normal & anomalous.
17. Understanding of gyromagnetic ratio, L-S & J-J coupling mechanisms.
18. Understanding of X-ray spectra, X-ray characteristics, Mosley's law.
19. Understanding of spectra of divalent & trivalent molecules, Franck-Condon principle.
20. Understanding of different types of emission & absorption spectroscopies, their principles, concepts & mechanisms.

Bachelor of Science (B.Sc.) - Specialization

Major - Physics

Semester - VI

Physics Practical Lab (VI)

(DSCP HPHY 611, Credits Practical 04, Practical Hours 120)

Maximum Practical Exam Marks = 100 Marks
(i) Internal Practical Exam Marks = 40 Marks
(ii) External Practical Exam Marks = 60 Marks (Duration : 4 hrs.)
Note: Out of the following experiments, 8 experiments must be done by the students in the semester.

<table>
<tr><th>Semester</th><th>Code of The Course</th><th>Title of The Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>VI</td><td>DSCP HPHY 611</td><td>Physics Practical Lab (VI)</td><td>7</td><td>4</td></tr>
<tr><td>Level of Course</td><td>Type of The Course</td><td colspan="3">Delivery Type of The Course</td></tr>
<tr><td>Introductory</td><td>Core</td><td colspan="3">Practical, One Hundred & Twenty Hours of Practicals including diagnostic and formative assessment during practical hours.</td></tr>
<tr><td>Prerequisites</td><td colspan="4">Physics and Mathematics courses of Central Board of Secondary Education or equivalent.</td></tr>
<tr><td>Objectives of The Course :</td><td colspan="4">➢ The objective of this course is to provide students with a comprehensive understanding of practical physics.
➢ The course aims to develop a strong foundation in the principles and concepts of practical physics in special reference to electronics, digital electronics & electrical domains.
➢ To provide hands-on experience in conducting experiments related to electricity and magnetism.
➢ To develop practical skills in using various electrical components and instruments.
➢ To reinforce theoretical concepts learned in the corresponding lecture course through practical applications.
➢ To enhance problem-solving and analytical skills by analysing experimental data and interpreting results.
➢ To promote scientific inquiry, critical thinking, and the ability to design and execute experiments.
➢ To foster teamwork and collaboration in conducting experiments and analysing results.
➢ To develop skills in accurately measuring and recording experimental data.</td></tr>
</table>

DSCP HPHY 611 : Physics Practical Lab (VI)

The inclusion of new experiments should be intimated and approved by the Convenor, Board of Studies before the start of the academic session. It is binding to have an experimental set-up of at least ten experiments listed below. In case the number of experiments performed by the student is less than eight, his marks shall be scaled down in the final examination on a pro-rata basis. Laboratory examination paper will be set by the external examiner out of eight or more experiments available at the center.

List of Experiments : Semester - VI

1. To determine the Stefan's constant by black body method.
2. To determine the Stefan's constant by solar cell method.
3. To study the temperature dependence of resistance of a semiconductor by four probe method.
4. To study the characteristics of a GM counter and verification of inverse square law for a given radioactive source.
5. To study the absorption coefficient in aluminium (Al) foil of varying thicknesses using GM counter.
6. To determine the Planck's constant by photocell (retarding potential method using optical filters, preferably five different coloured optical filters).
7. To determine the Planck's constant using solar cell.
8. To study the (1x8)/(1x4) demultiplexer using digital circuit platform.
9. To determine charge-to-mass ratio (e/m) by the Helical method.
10. To measure the magnetic field using ballistic galvanometer and search coil.
11. To study the variation of magnetic field of an electromagnet with current.
12. To measure the value of electric charge by Millikan's oil drop method.
13. To study the Lissajous's figures using cathode ray oscilloscope (CRO).
14. Any experiment according to undergraduate level physics theory.

Course Learning Outcomes:

Through these experiments, students will develop practical skills in experimental techniques, data collection, analysis, and interpretation. They will also enhance their understanding of fundamental concepts and principles in electronics. The lab experiences will foster critical thinking, problem-solving abilities, and the application of theoretical knowledge to real-world scenarios.

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