JAMIA MILLIA ISLAMIA
(A Central University by an Act of Parliament)

Department of Physics
Faculty of Natural Sciences

Maulana Mohammed Ali Jauhar Marg, New Delhi-110025 Tel.: 26984631, 26981717 Extn. 3212 / 3210
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The Minutes of the Meeting of Board of Studies held on 24.03.2017 at 3.00 P.M.

A meeting of the Board of Studies (BOS) of the Department of Physics was held on 24th March, 2017 at 3.00 PM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. M. Zulfequar
Prof. Lekha Nair
Dr. Asad Niazi
Dr. M.A.H. Ahsan
Dr. A. M. Siddiqui
Dr. Mohd. Shahid Khan
Dr. Anver Aziz
Dr. Syed Rashid Ahmad
Dr. Arun Singh
Dr. Somasri Sen
Mr. Pumlian Monga
Dr. Javid Ali
Dr. Raza Shahid

1. The minutes of the last meeting of BoS held on October 27, 2016 were confirmed.
2. The list of the examiners for Even Semesters of B.Sc. (H/P/S/Inst), M.Sc., B.Voc. (Solar Energy) and Pre-Ph.D. coursework for the session 2016-2017 was approved. The BoS also authorized the HOD to make suitable modification in the list of examiners/appoint new examiner, if there is a need for the same for smooth conduct of the examinations.
3. **Ph. D. related matters:**
   (A) Cancellation of Ph.D. admission of Ms. Uzma Khan:
   The BoS was informed that Ms. Uzma Khan registered under the supervision of Dr. S. Rashid Ahmad has not been coming to the Department and has not responded to the emails sent to her by her supervisor. The BoS also noted that she has also completed 5 years of registration. Keeping in view of all this; ***registration of Ms. Uzma Khan for the Ph.D. course stands cancelled***.
   (B) Cancellation of Ph.D. admission of Ms. Neetu:
   The BoS was informed that Ms. Neetu registered under the supervision of Dr. A.K. Hafiz has requested for the cancellation of her registration in the Ph. D. programme due to

personal reasons. ***The BoS approved cancellation of registration in Ph. D. of Ms. Neetu on her own request***.

(C) Cancellation of Ph.D. admission of Mr. Saeed Ahmad:
The BoS considered the application of ***Mr. Saeed Ahmad*** registered under Dr. Asad Niazi for the cancellation of his registration in Ph.D. as he has got admission in IIT. ***The BoS approved cancellation of registration in Ph. D. of Mr. Saeed Ahmad on his own request***.

(D) On the basis of their applications and the recommendations of their Supervisor(s), the BoS approved the inclusion of Co-supervisor in case of the following Research Scholars:

Name of Ph.D. student	Name of Supervisor (s)	**Additional Co-Supervisor(s)**
Mohd. Arif	Dr. Arun Singh (Supervisor)	**Professor Paula Vilarinho** **Department of Materials and Ceramic Engineering, University of Aveiro, *Portugal*** paula.vilarinho@ua.pt
Shagun Monga	Dr. Arun Singh (Supervisor)	**Professor Paula Vilarinho** **Department of Materials and Ceramic Engineering, University of Aveiro, *Portugal*** paula.vilarinho@ua.pt
Gaurav Jamwal	Dr. Asad Niazi (Supervisor)	**Dr. K. Asokan,** **Scientist–F, IUAC, Aruna Asaf Ali Marg, New Delhi-110067**
Anha Masarrat	Dr. Asad Niazi (Supervisor)	**Dr. K. Asokan,** **Scientist – F, IUAC, Aruna Asaf Ali Marg,New Delhi-110067**

4. The BoS also recommended the following as the **External Members of Board of Study (BoS)** of Department of Physics, after the completion of three year terms of the current External members:

1. Professor P.K. Bhatnagar
   Department of Electronic Sciences
   South Campus, University of Delhi, New Delhi.

2. Professor S. A. Hashmi
   Department of Physics and Astrophysics
   University of Delhi, Delhi.

5. The BoS also approved the revised syllabi of the following two papers of Pre-Ph.D. course:

(i) Selected Topics in Mathematical Physics
(ii) Research Methodology

6. To compile the revised syllabi of the various papers of B.Sc. and M.Sc. under the CBCS, the BoS constituted a committee comprising of the following faculty members:

(i) Prof. Lekha Nair
(ii) Dr. Mohd. Shahid Khan
(iii) Dr. Somasri Sen

7. The BoS also deliberated on the modalities of internal assessment/sessional tests for the B.Sc. and M.Sc. courses under the CBCS and suggested that the condition of passing in the internal assessment ***separately*** be ***done away*** and ***instead a student should only be required to pass in Total Marks in a paper***. It was felt that a proposal for the same may be forwarded to the Faculty Committee for consideration.

8. The BoS also approved the B. Voc. (Solar Energy) course to be run under the umbrella of DDU Kaushal Kendra as the same has already been approved by the Academic Council.

The meeting ended at 4.00 P.M. with thanks to the Chair.

(Dr. Saeed Uddin)
Professor & Head

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The Minutes of the Meeting of Board of Studies held on 09.05.2017 at 3.00 P.M.

A meeting of the Board of Studies (BoS) of the Department of Physics was held on 9th May, 2017 at 3.00 PM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. M. Zulfequar
Prof. Lekha Nair
Dr. Asad Niazi
Dr. A. M. Siddiqui
Dr. Mohd. Shahid Khan
Dr. Anver Aziz
Dr. Syed Rashid Ahmad
Dr. Somasri Sen
Mr. Pumlian Monga
Dr. Javid Ali
Dr. Raza Shahid

1. The minutes of the last meetings of BoS held on 24/03/2017, 19/04/2017 & 25/04/2017 were confirmed.

2. The distribution of theory courses for Pre-Ph.D. Course work, M.Sc. (Physics) and B.Sc. (H/P/I/S) for odd semester of the academic session 2017-2018 was approved. The BoS also authorized the HoD to make suitable modification in the distribution of the courses, if there is a need for the same.

3. **Ph.D. related matters:**
   (A) Transfer of Research Scholars Registered under Dr. A.K. Hafiz:
   Consequent upon the appointment of Dr. A.K. Hafiz in the Centre for Nanoscience and Nanotechnology, JMI, and the application of the Research Scholars registered under Dr. A.K. Hafiz for the transfer of their registration from Department of Physics

to Centre for Nanoscience and Nanotechnology, the BoS **recommended the transfer of following Research Scholars to Centre for Nanoscience and Nanotechnology:**

S.No.	Name of Research Scholar
1	Ms. Poonam Rani
2	Mr. Mohammad Imran
3	Ms. Jyoti Bansal

Ms. Ishtihadah Islam, registered under Dr. A.K. Hafiz, however, requested the BoS to maintain her registration with Department of Physics. She further requested the BoS to make Dr. A.K. Hafiz as her Co-Supervisor. The BoS appointed Dr. Azher Majid Siddiqui as Supervisor and Dr. A.K. Hafiz, Centre for Nanoscience and Nanotechnology, JMI as Co-Supervisor of Ms. Ishtihadah Islam.

(B) On the basis of their applications and the recommendations of their Supervisor(s), the BoS approved the inclusion of Co-supervisor in case of the following Research Scholars:

Name of Ph.D. student	Name of Supervisor	**Co-Supervisor**
Mr. Jai Shankar Singh	Prof. Saeed Uddin (Supervisor)	**Dr. Mohd. Shahid Khan** **Department of Physics, JMI**
Mr. Imran Ahmad Salmani	Dr. Mohd. Shahid Khan (Supervisor)	**Dr. M. Saleem Khan** **Associate Professor,** **Department of Applied Physics, Faculty of Engineering & Technology, MJP Rohilkhand University, Bareilly.**

(C) Minor change in the Research topic of Ms. Priya Darshni Kaushik:
The BoS considered the application of Ms. Priya Darshni Kaushik for minor change in her topic of research and approved the same as under:

Name of Ph.D. Student	Name of Supervisor/Co-Supervisor	Old Topic of Research	**New Topic of Research**
Priya Darshni Kaushik	Dr. Anver Aziz (**Supervisor**) Dr. Azhar M. Siddiqui (**Co-Supervisor**)	Study of the Effects of Band Structure Modifications in Semiconductor Heterostructures	**Effects of Structural Modifications in Graphene/SiC Semiconductor**

4. The BoS also approved the revised syllabi of the following two papers of B.Sc. (Hons.) Physics course:

(i)	Mathematical Physics –I	(PHB33C)
(ii)	Mathematical Physics –II	(PHB43C)

The meeting ended at 4.15 P.M.

(Dr. Saeed Uddin)
Professor & Head

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The Minutes of the Meeting of Board of Studies held on 09.11.2017

A meeting of the Board of Studies (BOS) of the Department of Physics was held on 9th November, 2017 at 3.00 PM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. M. Zulfequar
Dr. Asad Niazi
Dr. Mohd. Shahid Khan
Dr. Anver Aziz
Dr. Syed Rashid Ahmad
Dr. Somasri Sen
Mr. Pumlian Monga
Dr. Javid Ali

1. The minutes of the last meeting of BoS held on 22/09/2017 were confirmed.
2. The list of the examiners for B.Sc. (H/P/S/I) (Odd Semesters), and M.Sc. Physics (Odd Semesters) was approved.
3. The distribution of theory courses for M.Sc. (Physics) and B.Sc. (H/P/S/I) for even semesters of session 2017-2018 was approved.
4. The Course content of B.Sc. and M.Sc. was discussed and approved. The BoS also authorized the HoD to do minor modification in the course contents, if required.

The meeting ended at 4.00 P.M. with thanks to the Chair.

Saeeduddin

(Dr. Saeed Uddin)
Professor & Head

Draft

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Minutes of the Meeting of Board of Studies held on 23.03.2018

A meeting of the Board of Studies (BOS) of the Department of Physics was held on 23rd March 2018 at 3.00 PM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. Sushant G Ghosh (Centre for Theoretical Physics)
Prof. Zeeshan Husain Khan (Department of Applied Science & Humanities)
Prof. M. Zulfequar
Dr. Asad Niazi
Dr. Azher Majid Siddiqui
Dr. Anver Aziz
Dr. Syed Rashid Ahmad
Dr. Somasri Sen
Mr. Pumlian Monga
Dr. Arun Singh
Dr. Javid Ali
Dr. Raza Shahid

1. The minutes of the last meeting of BoS held on 09/11/2017 were confirmed.
2. The HoD welcomed the new members of the BoS, Professor Sushant G. Ghosh and Professor Zeeshan Husain Khan nominated by the Vice-Chancellor, J.M.I.
3. The list of the examiners for B.Sc. (H/P/S/I), M.Sc Physics. for all even semesters/Ph.D. Course Work Examination and B.Voc. in Solar Energy Course for Semetser-4 and 3rd year was approved.
4. The BoS approved the new codes assigned to the M.Sc. Semester-4 papers.
5. The BoS approved the addition of the Computational Methods in Physics under the Skill Enhancemement Course in B.Sc. Honours Semester-6 having code **PHB-61AL**.
6. The BoS appointed the Research Advisory Committee for the Ph.D. Research Scholars admitted during the last admission process in October 2017. This was done in accordance with the revised Ordinance IX, Para 3(c). The list of the RAC members of the concerned Research Scholars is attached herewith as Annexure-I.

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7. The BoS approved the extension of the Non-NET Fellowship of Mr. Tahir Murtaza working under the Supervision of Dr. Mohd. Shahid Khan for the fourth year. The BoS was satisfied with his progress.

8. The BoS considered the requests of the two candidates, Ms. Zara Aftab working under the Supervision of Professor Lekha Nair and Ms. Nisha Devi working under the Supervision of Dr. Anver Aziz for minor changes in their Ph.D. Theses topics. The BoS after discussion with the respective Supervisors approved the minor changes as follows:

A. Name of the Candidate: Ms. Zara Aftab
Name of Supervisor: Professor Lekha Nair
Old Topic: "Radiation damage of fusion reactor material effect of ion irradiation on Tungsten and Tungsten alloys"
New Topic: "Radiation processing of metal films: structural and morphological transformations on the nanoscales"

B. Name of the Candidate: Ms. Nisha Devi
Name of Supervisor: Dr. Anver Aziz
Old Topic: "Study of Doping In Group II-IV Semicinductor Solar Cells"
New Topic: "Study of Doping and Defects in Semiconductor Solar Cells"

The meeting ended at 4.00 P.M.

(Dr. Saeed Uddin)
Professor & Head

Syllabi of Undergraduate Theory Courses

Code	Course	Sections	Periods/week
PHY-UG101	Mechanics	HPVCS	3
PHY-UG102	Electronics	HPVCS	3
PHY-UG201	Oscillation and Waves	HPVCS	3
PHY-UG202	Thermal Physics	HPVCS	3
PHY-UG301	Electricity and Magnetism I	HPVCS	3
PHY-UG302	Optics	HPVCS	3
PHY-UG303	Mathematical Physics I	H	3
PHY-UG401	Electricity and Magnetism II	HPVCS	3
PHY-UG402	Quantum Mechanics I	HPVCS	3
PHY-UG403	Mathematical Physics II	H	3
PHY-UG501	Electromagnetic Theory	H,P	4,3
PHY-UG502	Solid State Physics I	H,P	4,3
PHY-UG503	Quantum Mechanics II	H	4
PHY-UG504	Statistical Physics	H	4
PHY-UG505	Digital Electronics	H	4
PHY-UG601	Atomic and Molecular Physics	H,P	4,3
PHY-UG602	Nuclear and Particle Physics	H,P	4,3
PHY-UG603	Solid State Physics II	H	4
PHY-UG604	Semiconductor Device Physics	H	4
PHY-UG605	Advanced Optics	H	4

PHY-UG101

Mechanics

3 Periods/week HPVCS

Unit 1: Fundamentals of Dynamics

Newton's Laws of motion, dynamics of a system of particles, centre of mass, conservation of momentum, impulse, variable mass system.

Work-energy theorem, potential energy,conservative and non-conservative forces, force as gradient of potential energy

Particle collisions, centre of mass and laboratory frame.

Inertial frames and non-inertial frames,uniformly accelerated system, centrifugal and Coriolis forces.

Unit 2: Rotational Dynamics

Angular momentum of a system of particles, torque and conservation of angular momentum, rotation about a fixed axis, moment of inertia tensor: its calculation for regular bodies, kinetic energy of rotation.

Unit 3: Gravitation

Newton's law of gravitation, inertial and gravitational mass, potential energy due to spherical shell and solid sphere, angular momentum conservation Kepler's laws.

Unit 4: Special Theory of Relativity

Lorentz transformations, simultaneity and order of events, Lorentz contraction and time dilation, velocity addition theorem. Expressions of momentum and energy.

Suggested books :

1. Kleppner & Kolenkow.
2. Feynman Lectures-Volume I,
3. Irodov-Problems in Physics,
4. Resnick-Special Theory of Relativity,
5. A.P. French-Newtonian Mechanics,
6. Berkeley Physics Course-Mechanics.

PHY-UG102
Electronics

3 Periods/week HPVCS

Unit 1: Circuits Analysis

Kirchhoffs Laws, Mesh and Node Analysis of Circuits. Networks, Equivalent Star (T) and delta (?) Networks. Star to Delta and Delta to Star Conversion. Network Theorems, Superposition theorem, Thevenins Theorem, Nortons theorem.

Unit 2: Semiconductor Diodes

Introduction, P and N Type Semiconductors. Energy Level Diagram. PN junction Diodes and its characteristics. Static and Dynamic Resistance. PN junction Rectifier Diode, Half-wave Rectifier, Full-wave Rectifiers its Ripple Factor and Efficiency. Idea of Filters. Zener Diode,Photo diode, LED.

Unit 3: Transistors

N-P-N and P-N-P Transistors, Characteristics of Commom base, Common Emitter and Common Collector configurations. Active, Cutoff, and Saturation Regions. Load line and Q- point. Amplifiers :- Amplifier and their classification, Class A, B, and C Amplifiers. Ideal amplifier, Voltage gain, current gain, Power gain, Input resistance, output resistance, load line.

Unit 4: Oscillators

Oscillators Principle and Classification. Barkhauson's Criterion for Self-sustained Oscillations. Essentials of Oscillators, RC Phase Shift Oscillator, Determination of Frequency. Wein-Bridge oscillator, Hartley Oscillator.

Suggested books:

1. Basic Electronics, D C Tayal,.
2. Principles of Electronics, V. K. Mehta.
3. Electronic Devices and Circuit by Robert Boylestad, Louis Nashelsky, Pearson Education.
4. Basic Electronics and Linear Circuits By N. N. Bhargava, D. C. Kulshreshtha, Tata McGrawHill.

PHY-UG201

Oscillation and Waves

3 Periods/week HPVCS

Unit 1: Harmonic Oscillations

SHM in one Degree of Freedom :-Simple pendulum, Mass- Spring system, Torsional Pendulum, Compound pendulum.
Linearity and Superposition Principle. Oscillations having equal frequencies and different frequencies (Beats). Superposition of Two Mutually Perpendicular oscillations. Lissajous Figures.

Unit2:Damped and Forced Oscillations

Free Damped Oscillations, Transient and Steady States, Amplitude, Phase, Resonance, Sharpness of Resonance, Power Dissipation and Quality Factor. Coupled Oscillators.

Unit 3:Vibrations in Continuous Systems

Transverse vibrations of Stretched Strings.Normal Modes of Stretched Strings. Plucked and Struck Strings.
Longitudinal vibrations in air and other continuous medium. Newton?s Formula for Velocity of Sound. Laplace?s correction.

Unit 4:Wave motion

Wave Equation. Solutions of wave equation. Wave front. Plane and Spherical Waves. Longitudinal and Transverse Waves. Phase and Group Velocities. Energy Transport in a wave. Intensity of Wave.
Standing Waves in a String : reflection at fixed and free ends. Melde?s Experiment. Longitudinal Standing Waves in Open and Closed Pipes.

Suggested Books:

1. Vibrations and Waves by A. P. French.(CBS Pub. & Dist., 1987)

2. The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988)

3. An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973)

4. Waves: BERKELEY PHYSICS COURSE (SIE) by Franks Crawford (Tata McGrawHill, 2007).

PHY-UG202
Thermal Physics

3 Periods/week HPVCS

Unit 1: Kinetic theory of gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification. Mean free path. Transport phenomena, viscosity.

Unit 2: Ideal and real gases

Equation of state for ideal gas, internal energy, specifics heat, entropy.
Van der Waal's equation, critical constants and law of corresponding states. Joule-Thompson effect.

Unit 3: Thermodynamics

First and second laws. Reversible and irreversible processes. Carnot's theorem. Clausius inequality. Absolute scale of temperature. Entropy. Thermodynamic Relations and their applications.

Unit 4: Radiation

Kirchoff's law. Black body radiation. Wien's displacement law. Stefan-Boltzmann law. Planck's law of radiation and qualitative introduction to quanta of radiation.

Suggested books:

1. A Text book of heat: M. N Saha and B.N Srivastava (Science book Agency Publications)
2. Heat and Thermodynamics: An Intermediate Textbook By Mark Waldo Zemansky, Richard Dittman (McGraw-Hill, 1981).
3. Thermal Physics : Garg, Bansal and Ghosh (Tata McGraw-Hill, 1993).
4. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics: Francis W. Sears & Gerhard L. Salinger.(Narosa, 1986).

PHY-UG301

Electricity and Magnetism I

3 Periods/week HPVCS

Unit 1: Vector Calculus

Scalars and vectors, dot and cross products. Gradient of a scalar field, divergence and curl of a vector field. Line, surface and volume integrals involving vector fields. Gauss' , Green's and Stokes' theorems.

Unit 2: Electrostatics

Coulomb's law, Calculation of electric field for simple distributions of charges. Electrostatic potential, Gauss' law and its applications. Capacitors, electrostatic field energy. Method of images. Poisson and Laplace's equations.

Unit 3: Magneto-statics

Magnetic induction B. Biot-Savart law. Ampere's law. Fields due to a straight wire and a circular current loop. Magnetic dipole. Circular current and solenoid.

Unit 4: Faraday's law

Electromagnetic induction: Integral and differential forms. Induced electric field and emf. Mutual and self-inductance. Transformers. Magnetic field energy.

Suggested books:

1. Introduction to Electrodynamics by D.J. Griffiths (Prentice Hall of India Private Limited)
2. Electricity and Magnetism by A.S. Mahajan and A.A. Rangwala (Tata McGraw Hill)
3. Electricity and Magnetism, Berkeley Physics Course ed. E.M. Purcell
4. Physics, Vol. 2 Halliday and Resnick
5. Feynman Lectures in Physics, Vol II.

PHY-UG302

Optics

3 Period/week HPVCS

Unit 1. Interference :

Coherent sources, Young's Double slit experiment, Division of wave front. Fresnel's bi-prism. Division of amplitude. Interference in thin films. Newton's rings. Michelson's interferometer.

Unit 2. Diffraction :

Fraunhofer diffraction at single, double and N slits. Fresnel diffraction at a straight edge and circular aperture. Cornu-spiral. Half-period zones. Zone plate. Diffraction grating.

Unit 3. Polarization :

Plane, circular and elliptical polarization of light. Double refraction. Nicol prisms. Wave plates. Optical activity.

Unit 4. Miscellaneous Topics :

Fermat's principle of geometrical optics. Huygen's principle. Resolving power of optical in- strunents and diffraction grating. Principle of lasers and holography.

Suggested Books :

1. A. K.Ghatak : Optics
2. Jenkins and White : Fundamentals of Optics
3. Max Born andf Emil Wolf : Principles of Optics

PHY-UG303

Mathematical Physics I

3 Periods/week H

Unit 1: Linear Algebra

Vector spaces. Linear independence. Basis. Dimension. Linear trans- formations. Matrices. Subspaces. Quotient space. Inner product. Infinite dimensional HIlbert spaces.

Unit 2. Differential and integral calculus of many variables.

Partial differentiation. Differential forms. Curvilinear coordinates. Line, surface and volume integrals.

Unit 3: Complex Analysis

Analytic functions, Cauchy-Reimann conditions; Cauchy integral theorem, Taylor and Laurent series;

Calculus of Residues and its application in evaluating integrals.

Unit 4: Ordinary differential equations and dynamical systems

Systems of equations. Conservative and dissipative systems. Stability and Liapunov exponents. Attractors. Chaos.

Suggested Books :

1. Choose proper books

PHY-UG401

Electricity and Magnetism II

3 Period/week HPVCS

Unit 1 : Current and circuits

Current density, steady and non-steady currents and continuity equation, rise and decay of currents in LR and CR circuits, Complex impedance and reactance, frequency response. Series and parallel circuits, resonance, Q factor, Power dissipation and power factor.

Unit 2 : Electrostatic fields in matter

Dielectrics, polarization and the electric displacement vector D. Susceptibility, permittivity, dielectric constant. Energy in dielectric systems, forces on Dielectrics, Clausius-Massotti equation, Polar molecules. The Langevin formula.

Unit 3 : Magnetic fields in matter

Magnetization. Dia-, para- and ferro-magnetism. The field of a magnetized object. Bound currents. Ampere's law in magnetized medium. Magnetic field intensity vector H. Magnetic susceptibility and permeability. Ferromagnetism. Energy loss in Hysteresis and the B-H curve.

Suggested Books

1. Introduction to Electrodynamics, D.J. Griffiths (Prentice Hall of India Private Limited)
2. Electricity and Magnetism A.S. Mahajan and A.A. Rangwala (Tata McGraw Hill)
3. Electricity and Magnetism, Berkeley Physics Course ed. E.M. Purcell
4. Physics Vol. 2 Halliday and Resnick

PHY-UG402

Quantum Mechanics I

3 Period/week HPVCS

Unit 1: Review of the old quantum theory

Plank's quantum hypothesis, Einstein's photon concept. de Broglie waves and the wave- particle duality.

Unit 2: Schrodinger's wave equation

Wave function and the Schrodinger equation. Born's interpretation of the wave function. One dimensional potential well and barrier problems. The harmonic oscillator problem.

Unit 3: Operators and matrices

Hilbert space, orthonormal bases. Linear operators. Expectation values. Eigenvalues of Hermitian and unitary operators. Commutators. Heisenberg's uncertainty relations.

Unit 4: The three-dimensional problem

Spherically symmetric potential. Angular momentum operator and its eigenvalues. Commutation Relations. Spin of the electron. Hydrogen atom and the degeneracy of energy levels.

Suggested books :

1. Beiser : Concepts in Modern Physics
2. Mani and Mehta : Modern Physics
3. Bernstein, Fishbane & Gasiorowicz: Modern Physics
4. Schwabl : Quantum Mechanics
5. Ghatak : Quantum Mechanics
6. Gasiarowicz : Quantum Physics
7. Bransden and Joachain: Quantum Mechanics
8. Thankappan: Quantum Mechanics

PHY-UG403

Mathematical Physics II

3 Periods/week H

Unit 1: Fourier series and transform:

Expansions of functions of arbitrary periods; even and odd functions, half range expansions; complex form; Fourier Transform.

Dirac Delta Function, Fourier series and transform. integral representation of the delta function;

Unit 2: Special Functions

Gamma function. Legendre polynomials. Associated Legendre polynomials. Hermite polynomials. Bessel functions.

Unit 3: Differential Equations of Mathematical Physics

Laplace, Heat, Helmholtz, and wave equations. Method of separation of variables in the Cartesian, cylindrical and spherical coordinates; with examples.

Unit 4: Probability

Sample space and probability,independent events, conditional probability, random variables, Binomial, normal and Poisson distributions, continuous random variable, Normal distribution.

Suggested books:

1. Put names of books here.

PHY-UG501

Electromagnetic Theory

4,3 Periods/week H,P

Unit 1: Introduction

Electromagnetic Units, Maxwell's Equations in vacuum and in media, boundary conditions, electromagnetic potentials, gauge transformations.

Unit-2:Boundary value problems in electrostatics

Unit-3:Magnetostatics

Biot and Savart law, equations of magneto-statics and Amperes law, magnetic induction for a circular current loop. Magnetic moment. Force, torque on localized current distribution in a external magnetic induction field.

Unit-4:Electromagnetic waves

Plane waves in a non-conducting medium. Linear and circular polarization, stokes parameters, reflection and refraction at a plane interface, Brewster's angle, total internal reflection.

Suggested books:

1. Introduction to Electrodynamics D.J. Griffiths (Prentice Hall of India Private Limited)

2. Foundations of Electromagnetic Theory J.R. Reitz, F.J. Millford and R.W. Christry (Narosa Publishing House)

3. Introduction to Electromagnetic Field and Waves Corson and Lorrain

PHY-UG502

Solid State Physics I

4,3 Periods/week H,P

Unit 1: Crystal Structure

Crystalline state of solids, Lattice Translation Vector, Unit cell, Wigner-Seitz cell, Bravais lattice, Miller indices, Diffraction of X-rays, Bragg's law, Laue's equations, Powder method

Unit 2: Atomic bonding

Inter-atomic forces and classification of solids, Bond dissociation Energy, Cohesive Energy of ionic crystal, Covalent bond, Metallic bonding, Van der Waals bonding.

Unit 3: Lattice Dynamics

Linear Mono-atomic and Di-atomic molecules chains, Acoustical and optical phonons, Qualitative Description of the Phonon spectrum in solids.

Unit 4: Electrical Conductivity

Free electron theory, Sommerfeld model, Fermi level, Density of states, Electrical conductivity of metals and its temperature dependence, Weidemann-Franz law, Hall Effect.

Suggested books:

1. Charles Kittel
2. Henry Lipson
3. Charles S Barrett
4. Azaroff L. V
5. Cochran W
6. Wahab.M.A., Introduction to Solid State Physics.

PHY-UG503

Quantum Mechanics II

4 Period/week H

Unit 1 : Wave Functions

Position and momentum space wave-functions. Time evolution of Gaussian wave packets.

Schrodinger equation. Commutator relations. Probability current and continuity equation. Ehrenfest theorem.

Unit 2: Angular Momentum

Angular momentum operator and relation to rotations. Eigenvalues and eigenfunctions of the angular momentum. Spherical harmonics.

Spin angular momentum. Stern-Gerlach Experiment.

Addition of angular momenta.

Unit 3: Potential and Perturbation

Central Potentials and bound states. Degeneracies of eigenvalues. External electric and magnetic fields and Zeeman effect.

Suggested books :

1. Beiser : Concepts in Modern Physics
2. Mani Mehta : Modern Physics
3. Bernstein, Fishbane and Gasiorowicz: Modern Physics
4. Schwabl : Quantum Mechanics
5. Ghatak : Quantum Mechanics
6. Gasiarowicz : Quantum Physics
7. Bransden and Joachain: Quantum Mechanics
8. 8. Thankappan: Quantum Mechanics

PHY-UG504

Statistical Mechanics

4 Period/week H

Unit 1:

Phase Space, Canonical Ensemble. Thermodynamic quantities. Classical ideal gas. Gibb's paradox.

Unit 2:

Heat capacity of solids. Einstein theory. A two-level system: negative temperature.

UNIT 3:

The canonical ensemble; probability distribution; Equipartition theorem; internal modes in a gas; the Debye model; radiation;

UNIT 4:

Grand canonical ensemble and quantum statistics: the ideal Fermi gas; electrons in a metal; the ideal Bose gas; photons; Bose-Einstein condensation.

Suggested books:

1. F. Reif : Fundamentals of Statistical and Thermal Physics.
2. H. B. Callen: Thermodynamics and an Introduction to Thermostatistics, John Wiley and Sons.
3. Greiner, Neiser and Stocker: Thermodynamics and Statistical Mechanics; Springer.

PHY-UG505

Digital Electronics

4 Period/week H

Unit 1 : Binary numbers and logic gates

Binary, octal, hexadecimal and decimal Number systems. Binary arithmatic. Boolean algebra. De Morgan Theorem. Logic Gates. Karnaough Maps.

Unit 2 : Noise

Noise in electrical circuits. Transmission of binary data as voltage pulses. Corruption of data because of noise. Error detection : Parity. Error correcting codes : Hamming distance, Hamming (7,4) codes. Hadamard code. Elementary introduction to coding theory.

Unit 3 : Logic families

Introduction to different logic families, like RTL, DTL, HTL, IIL, TTL, ECL, CMOS, their merits and demerits. Basic concepts of fan in and fan out, sinking and sourcing of current. Case study of TTL family, voltage levels, TTL NAND gate, totem-pole and open collector output.

UNIT 5 : Circuits

Arithmetic Circuits : Binary addition and subtraction. Half Adders and Full Adders and Subtractors.

Data processing circuits : Multiplexers, De-multiplexers, Decoders, Encoders, Parity Checkers.

Sequential Circuits : Flip-Flops.

Shift registers : - Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out, and Parallel-in-Parallel-out Shift Registers.

Counters : Asynchronous and Synchronous Counters. Ring Counters. Decade Counter.

D/A and A/D conversion

Suggested Books: 1. Digital principles and applications By Donald P. Leach & Albert Paul Malvino, 2. 3. Digital Fundamentals, 3rd Edition by Thomas L. Floyd (Universal Book Stall, India, 1998). Digital Electronics by R.P. Jain, 4. Digital Electronics by V K Puri, TMH.

PHY-UG601

Atomic and Molecular Physics

4 Period/week H,P

Unit 1:

Pauli's Exclusion Principle. Fine structure. Spin-orbit coupling. Vector Model. L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms.

Unit 2:

Electron spin angular momentum. Larmors Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman effect; Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen -Beck and Stark effect

Unit 3:

Rotational Energy levels, Selection rules and pure rotational spectra of a molecule. Vibrational energy levels, selection rules and vibration spectra. Rotation-vibration energy Levels, selection rules and spectra. Determination of internuclear distance. Raman Effect, Stoke's and Anti-Stoke's Lines.

Unit 4: Hydrogen molecule. Molecular structure. Larger molecules?

Suggested books:

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book, 1987).
2. Introduction to Atomic Spectroscopy by H.E. White (McGraw Hill).
3. Modern Physics by Mani and Mehta
4. Physics of Atoms and Molecules, Bransden and Joachain 2nd Edition (Pearson 2011).
5. Molecular Spectroscopy, C.N. Banwell. (Tata-McGraw-Hill).

PHY-UG602

Nuclear and Particle Physics

4,3 Period/week H,P

Unit 1: Basic Concepts

Nuclear forces. Nuclear size, mass, charge, spin, magnetic moment, stability and binding energy. nuclear fission and fusion.

Unit 2: Radioactivity

Radioactive decay constant, half life and mean life. Radioactive transformations and equilibrium. Natural radioactive series.

Alpha decay. Gamow's theory. Beta decay. Pauli's neutrino hypothesis. Electron capture process.

Unit 3: Nuclear models and reactions

The liquid drop model of a nucleus. Weizsacker's semi-empirical mass formula. The shell model of a nucleus

Nuclear reactions. Threshold energy. Energy production in stars by proton-proton and carbon cycle.

Unit 4: Elementary Particles

Fundamental interactions in nature. Classification of elementary particles. Photons, leptons, mesons and baryons. Quantum numbers: isospin, strangeness, and charm. Quarks and confinement. Conservation laws.

Suggested books:

1. A. Beiser : Concepts of Modem Physics.
2. I. Kaplan : Nuclear Physics.
3. Bernard L. Cohen : Concepts of Nuclear Physics (Tata MCGraw Hill, 1998, New Delhi)
4. R.A. Dunlap: Introduction to the Physics of Nuclei and Particles (Singapore Thomson Asia 2004)
5. Kenneth S. Krane: Introductory Nuclear Physics (John Wiley and Sons, 1988)

PHY-UG603

Solid State Physics II

4 Period/week H

Unit 1: Band Theory of Solids

Bloch Theorem, Electron in periodic field: Kronig Penney model, Brillouin zones, Effective mass of electron, Origin of Band Gap, Insulator, semiconductor and metals.

Unit 2: Magnetic Properties of Matter

Response of substance to magnetic fields, Dia-, Para- and Ferromagnetic materials,

Electron spin and magnetic moment. Measurement of the susceptibility of paramagnetic substances, Langevin's theory of dia and paramagnetic substances,Curie-Weiss Law, Theory of ferro- magnetism.

Unit 3: Dielectric Properties of Solids

Polarization and Susceptibility, The local field, Dielectric Constant and Polarizability, Clausius- Massotti Equation, Sources of Polarizability, Classical Theory of Electronic Polarizability, Frequency Dependence of Total Polarizability.

Unit 4: Superconductivity

Electrical resistivity, Meissner Effect, Supercurrents and Penetration Depth, London Equations, Critical Field and Critical Temperature, Type I and Type II Superconductors,Flux Quantization, The Josephson Effects and Tunneling, High Temperature Ceramic superconductors.

Suggested books:

1. Charles Kittel
2. Henry Lipson
3. Charles S Barrett
4. Azaroff L. V
5. Cochran W
6. Wahab.M.A., Introduction to Solid State Physics.

PHY-UG604

Semiconductor Device Physics

4 Period/week H

Unit 1: Semiconductor Properties of Matter

Intrinsic Semiconductors, Extrinsic Semiconductors, Carrier concentration and Fermi level for Intrinsic Semiconductors, Carrier concentration, Fermi level and conductivity for Extrinsic Semiconductors.

Unit 1 : Modulation and Demodulation

Modulation and demodulation techniques of AM, FM and PM, Pulse analog modulation, sampling theorem, Pulse Digital modulation

Unit 2 : Waveshaping Circuits

Comparators, Schmitt trigger, square wave, triangular wave, pulse, voltage time-base and staircase generators. Sinusoidal oscillators Phase shift, Wien Bridge and crystal oscillator

.

Unit 3 : Semiconductor Devices :
Intrinsic and extrinsic semiconductors : doping, carrier concentration, charge transport; p-n junctions: abrupt, linearly graded and diffused junction, depletion region, I-V characteristics, junction capacitance; zener diode, tunnel diode, Transistors Construction and working of BJT, JFET, MOSFET, UJT, relaxation oscillator.

Unit 4 : Transistor hybrid model
Low frequency small signal transister model two port device and hybrid model, the h parameters, analysis of a transistor amplifier circuit using h parameters, Miller's theorem and it's dual, high frequency hybrid pi model conductances and capacitances

Suggested books:

1. Communication Systems, Simon Haykin, Wiley
2. Microelectronics, Millman, McGraw Hill
3. Integrated Electronics, Millman and Halkias
4. Physics of Semiconductor Devices, S M Sze and Kwok K Ng, Wiley

PHB605

Advanced Optics

4 Period/week H

Unit 1: Advance Wave Optics

Fermat's Principle and the Laws of Refraction. Elements of transfer matrix method. Harmonic Waves: Superposition of Harmonic Waves, Multiple Beam Interferometry- Plane Parallel Plate and Fabry-Perot Etalon; Kirchhoff Fresnel Integral, Fresnel Diffraction, Far Field Approximation, and Fraunhofer Observation. Coherence theory: Spatial Coherence, Temporal Coherence, Wave trains and Quasi-Monochromatic Light, Superposition of Wave trains. Principle of Laser: Process and applications

Unit 2: Wave-guides and Fiber Optics

Wave Guides, Guided Waves, Planar Wave guide, Propagating and Evanescent Waves, Restrictive Conditions for Mode Propagation, Phase Condition for Mode Formation, TE - Modes or s- Polarization. TM - Modes or p-Polarization, Fiber Optics Waveguides: Step index fiber and Graded index fiber, pulse dispersion and distortion in optical fibers. Modes in a Dielectric Waveguide.

Unit 3: Fourier Transformation and Holography
Fourier Transformation, The Fourier Integrals, Fourier Transform Spectroscopy. Holography: Recording of the Interferogram, Recovery of Image with Same Plane Wave.

Unit 4: Optical Constants and Non-linear optics Optical Constants of Dielectrics, The Wave Equation, Electrical Polarizability and Refractive Index, Determination of Optical Constants, Fresnels Formula and Reflection Coefficients, Sellmeier Formula, Nonlinear optical media: second and third order harmonic generation, Kerr and Pockel effects, anisotropic and dispersive optical media.

Unit 5: Introduction to Modern Optics Concepts of Nanophotonics and applications, Photonic Crystals- One, Two and Three dimensional photonic crystals,

1. Optical Electronics Ghatak and Thyagarajan
2. Optics Born and Wolf
3. Optics K. K. Sharma
4. Nanophotonics Paras N. Prasad

B.SC.(Hons)

Sl. No.	Name of the Paper	Paper Code	Credits	Periods/week
Semester I				
1	Mechanics	PHB-11C	3	3
2	Electronics	PHB-12C	3	3
3	Digital Electronics	PHB-11E	4	4
4	Lab 1	PHB-11L	2	4
Semester II				
5	Thermal Physics	PHB-21C	3	3
6	Oscillation & Waves	PHB-22C	3	3
7	Development of Modern Phys	PHB-21E	4	4
8	Lab II	PHB-21L	2	4
Semester III				
9	Electricity & Magnetism I	PHB-31C	3	3
10	Optics	PHB-32C	3	3
11	Mathematical Physics I	PHB-33C	4	4
12	Instruments & Measurements	PHB-31A	4	4
13	Lab III	PHB-31L	2	4
Semester IV				
14	Electricity & Magnetism II	PHB-41C	3	3
15	Quantum Mechanics	PHB-42C	3	3
16	Mathematical Physics II	PHB-43C	4	4
17	Properties of Matter	PHB-41E	4	4
18	Lab IV	PHB-41L	2	4
Semester V				
19	Electromagnetic Theory	PHB-51C	3	3
20	Atomic & Molecular Physics	PHB-52C	3	3
21	Solid State Physics I	PHB-53C	3	3
22	Classical Mechanics	PHB-51E	4	4
23	Lab V	PHB-51L	3	6
Semester VI				
24	Solid State Physics II	PHB-61C	3	3
25	Nuclear &Particle Physics	PHB-62C	3	3
26	Statistical Mechanics	PHB-63C	3	3
27	Computational Methods in Phys	PHB-61AL	4	4
28	LAB VI	PHB-61L	3	6

Semester I

Core Course **Mechanics** **PHB-11C**

Unit I: Fundamentals of Dynamics

Newton's Laws of motion, dynamics of a system of particles, centre of mass, conservation of momentum, impulse, variable mass system. Work-energy theorem, potential energy, conservative and non-conservative forces, force as gradient of potential energy. Particle collisions, centre of mass and laboratory frame. Inertial frames and non-inertial frames, uniformly accelerated system,

Unit II: Rotational Dynamics

Angular momentum of a system of particles, torque and conservation of angular momentum, rotation about a fixed axis, moment of inertia tensor: its calculation for regular bodies, kinetic energy of rotation; physics in rotating coordinate system, centrifugal and Coriolis forces.

Unit III: Gravitation

Newton's law of gravitation, inertial and gravitational mass, potential energy due to spherical shell and solid sphere, angular momentum conservation Kepler's laws.

Unit IV: Special Theory of Relativity I

Michelson Morley experiment, Lorentz transformations, simultaneity and order of events, Lorentz contraction and time dilation, velocity addition theorem.

Reference Books:

1. An introduction to mechanics : Kleppner & Kolenkow.
2. Feynman Lectures-Volume I,
3. Problems in Physics : Irodov
4. Special Theory of Relativity : Resnick
5. Newtonian Mechanics : A.P.French,
6. Mechanics : Berkeley Physics Course.

Semester I

Core Course **Electronics** **PHB-12C**

Unit I: Circuits Analysis

Kirchhoffs Laws, Mesh and Node Analysis of Circuits. Networks, Equivalent Star (T) and delta Networks. Star to Delta and Delta to Star Conversion. Network Theorems, Superposition theorem, Thevenin Theorem, Norton theorem.

Unit II: Semiconductor Diodes

Introduction, P and N Type Semiconductors. Energy Level Diagram. PN junction Diodes and its characteristics. Static and Dynamic Resistance. PN junction Rectifier Diode, Half-wave Rectifier, Full-wave Rectifiers its Ripple Factor and Efficiency. Idea of Filters. Zener diode,,Photo diode, varactor diode, LED.

Unit III: Transistors and Amplifiers

N-P-N and P-N-P Transistors, Characteristics of CB, CE and CC configurations. Active, Cutoff, and Saturation Regions. Load line and Q- point. Amplifiers and their classification, Class A, B, and C Amplifiers. Ideal amplifier, Voltage gain, current gain, Power gain, Input resistance, output resistance, load line.

Unit IV: Operational Amplifier

Principle of Operational Amplifier, Properties of ideal OPAMP, Open-loop and closed loop gain, Frequency response, CMMR, Slew rate, Virtual ground, Applications of operational Amplifiers : inverting, non-inverting, adder, subtractor, integrator, differentiator.

Reference Books:

1. Basic Electronics : D C Tayal,.
2. Principles of Electronics : V. K. Mehta.
3. Electronic Devices and Circuit : Robert Boylestad, Louis Nashelsky,
4. Basic Electronics and Linear Circuits : N. N. Bhargava, D. C. KulShreshtha.

Semester I

Choice Based Elective | **Digital Electronics** | **PHB-11E**

Unit I: Number system and codes

Introduction to decimal, binary, octal, hexadecimal number system, Inter conversion of binary, decimal, BCD, Octal and hex., BCD codes, Excess-3, grey codes. Simple binary arithmetic, binary addition, binary subtraction, 1`s and 2`s compliment of a binary number.

Unit II: Logic Gates

OR, AND, NOT NAND, XOR, NOR and XNOR gates, symbols and truth tables. NAND & NOR gates as universal gates, Logic families: DTL, TTL, RTL, ECL, DCTL, CMOS Logic and their merits and demerits.

Unit III: Boolean algebra

De Morgan's Theorems. Boolean laws. Simplification of logic circuit using Boolean algebra. Fundamental products. Minterms and Maxterms. Conversion of a truth table into an equivalent circuit by (1) SOP (2) POS method. Algebraic simplification, k-Maps, pairs, quads and octets, Karnaugh simplifications, Don't care conditions,

Unit IV: Adder, Flip-flop, Registers and Counters

Binary Adders (Half Adder, Full adder). Flip flops: RS Latches, Level clocking (Clocked SR flip flop), D latch, Edge triggered JK Flip Flop, JK Master Slave flip flop, T type Flip Flop. Registers- Shift Registers, synchronous & Asynchronous counters, Applications of Counters.

Reference Books:

1. Digital Electronics : Gothman
2. Digital Principals & Applications : Malvino & Leach
4. Digital Computer Electronics : A.P.Malvino
5. Analog and Digital Electronics : Peter.H.Beards.
6. Integrated Electronics : Millman & Halkias

Semester I

Physics Practical **Lab I** **PHB-11L**

Mechanics & Oscillation

List of Experiments :

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine **g** using simple pendulum.
3. To study the Motion of Spring and calculate Spring constant by static and dynamic method. (4)
4. To determine the Moment of Inertia of a Flywheel. (4)
5. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method). (2)
6. To determine the Young's Modulus of a rod by bending by Optical Lever Method. (1)
7. To determine the value of g using Bar Pendulum. (4)
8. To determine the value of g using Kater's Pendulum. (4)
9. To determine surface tension of a fluid by capillary rise method. (3)
10. To determine the coefficient of viscosity of a liquid by Stoke's law. (3)
11. To determine the surface tension of a liquid by Jaeger's method.(2)
12. To determine the modulus of rigidity of material of a wire by Maxwell's needle. (1)

Semester II

Core Course **Thermal Physics** **PHB-21C**

Unit I: Kinetic theory of gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification. Mean free path. Transport phenomena, viscosity.

Unit II: Ideal and Real gases

Equation of state for ideal gas, internal energy, specific heat, entropy, deviation from ideal gas, Andrew’s experiment, Van der Waal's equation, critical constants and law of corresponding states, Joule-Thompson effect.

Unit III: Thermodynamics

Zeroth, First and second laws. Reversible and irreversible processes. Carnot's theorem. Clausius inequality. Absolute scale of temperature. Entropy. Thermodynamic Relations and their applications.

Unit IV: Thermodynamic Functions

Maxwell’s relations and their applications. Change of phase. Equilibrium between a liquid and its vapour. Clausius–Clapeyron equation. Triple point with examples from physics. Second order phase transitions.

Reference Books:

1. A Text book of heat: M. N Saha and B.N Srivastava
2. Heat and Thermodynamics: Zemansky, Richard Dittman .
3. Thermal Physics : Garg, Bansal and Ghosh .
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Sears &Salinger.

Semester II

Core Course **Oscillation and Waves** **PHB-22C**

Unit I: Harmonic Oscillations

Simple harmonic oscillator, Examples in one Degree of Freedom: Simple pendulum, Mass-Spring system, Torsional Pendulum, Compound pendulum, Linearity and Superposition Principle. Oscillations having same frequency and different frequencies, Superposition of two mutually perpendicular oscillations. Lissajous Figures.

Unit II: Damped and Forced Oscillations

Free Damped Oscillations, Transient and Steady States, Amplitude, Phase, Resonance, Sharpness of Resonance, Power Dissipation and Quality Factor.

Unit III: Vibrations in Continuous Systems

Transverse vibrations of stretched strings. Normal modes of stretched strings. Pluck and struck strings. Longitudinal vibrations in air and other continuous medium. Newton's formula for Velocity of Sound. Laplace's correction.

Unit IV: Wave Motion

Wave Equation. Solutions of wave equation. Wave front. Plane and Spherical Waves. Longitudinal and Transverse Waves. Phase and Group Velocities. Energy Transport in a wave. Intensity of Wave. Standing waves in a string, reflection at fixed and free ends. Melde's experiment. Longitudinal Standing Waves in Open and Closed Pipes.

Reference Books:

1. Vibrations and Waves : A. P. French.
2. The Physics of Waves and Oscillations : N.K. Bajaj
3. An Introduction to Mechanics : Kleppner and Kolenkow
4. Waves: Berkley Physics Course : Franks Crawford

<u>Semester II</u>

Physics Practical **Lab II** **PHB-21L**

Electronics (Analog) & Thermal Physics

List of Experiments :

1. To study V-I characteristics of PN junction diode (4)
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator. (4)
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration. (4)
4. To study growth and decay of charge on a condenser in RC circuit. (4)
5. To study Half wave and Full wave rectifier and find their ripple factor with various filters. (4)
6. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee's disc method. (2)
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier. (2)
8. To verify the network theorems. (2)
9. To determine Stefan's constant (2)
10. To determine the frequency of the mains with Melde's experiment.(3)

Semester II

Choice Based Elective **Development of Modern Physics** **PHB-21E**

Unit I: Radiation

Black body radiation, Planck radiation formula, Photoelectric effect, X- rays, Compton Scattering, X-ray diffraction,

Unit II: Wave nature of particles

Matter wave hypothesis of de Broglie, wave packets, phase and group velocities, Born's interpretation of the wave function, Diffraction of particles Davisson and Germer's experiment, G.P.Thomson's experiment, uncertainty principle.

Unit III: Atomic Structure

Rutherford scattering, Atomic model. Atomic spectra, energy levels, Bohr theory, quantum numbers, Franck-Hertz experiment.

Unit IV: Nuclei and particles

Nuclear composition, binding energy, Nuclear fission and fusion, Classification of fundamental forces, Nuclear forces and Elementary particles. Qualitative introduction to standard models of Particle physics and Cosmology.

Reference Books:

1. A. Beiser : Concepts of Modern Physics
2. H. H. Mani and G. K. Mehta : Modern Physics
3. Max Born : Atomic Physics
4. Urey and Ruark : Atoms and Quanta

Semester III

Core Course **Electricity & Magnetism I** **PHB-31C**

Unit I: Vector Calculus

Scalars and vectors, dot and cross products. Gradient of a scalar field, divergence and curl of vector field. Line, surface and volume integrals involving vector fields. Gauss' , Green's and Stokes' theorems.

Unit II: Electrostatics

Coulomb's law, Calculation of electric field for simple distributions of charges. Electrostatic potential, Gauss' law and its applications. Capacitors, electrostatic field energy. Method of images. Poisson and Laplace's equations.

Unit III: Magneto-statics

Magnetic induction B. Lorentz force, Biot-Savart law. Ampere's law. Fields due to a straight wire and a circular current loop. Magnetic dipole. Circular current and solenoid.

Unit IV: Faraday's law

Electromagnetic induction: Integral and differential forms. Induced electric field and emf. Mutual and self-inductance. Transformers. Magnetic field energy.

Reference Books:

1. Introduction to Electrodynamics : D.J. Griffiths
2. Electricity and Magnetism : A.S. Mahajan and A.A. Rangwala
3. Electricity and Magnetism : Berkeley Physics Course ed. E.M. Purcell
4. Physics (Vol. 2) : Halliday and Resnick
5. Feynman Lectures in Physics (Vol II)

Semester III

Core Course **Optics** **PHB-32C**

Unit I: Interference :

Coherent sources, Young's Double slit experiment, Division of wave front. Fresnel's bi-prism. Division of amplitude. Interference in thin films. Newton's rings. Michelson's interferometer.

Unit II: Diffraction :

Fraunhofer diffraction at single, double and N slits. Fresnel diffraction at a straight edge and circular aperture. Cornu-spiral. Half-period zones. Zone plate. Diffraction grating.

Unit III: Polarization :

Plane, circular and elliptical polarization of light. Double refraction. Nicol prisms. Wave plates. Optical activity.

Unit IV: Miscellaneous Topics :

Fermat's principle of geometrical optics. Huygen's principle. Resolving power of optical instrunents and diffraction grating. Principle of lasers and holography.

Reference Books:

1. Optics : A. K.Ghatak
2. Fundamentals of Optics : Jenkins and White
3. Principles of Optics : Max Born andf Emil Wolf
4. Optics : Eugene Hecht

Semester III

Core Course **Mathematical Physics I** **PHB-33C**

Unit I: Matrices and Linear Vector Space :

Matrix algebra; Different types of matrices; Quotient space; Inner Product; Abstract Systems; Binary Operations; Groups; Fields; Vector Spaces; Subspaces; Linear Independence and Dependence; Basis; Dimensions; Change of basis; Homomorphism, Isomorphism, Linear and Non-singular Transformations.

Unit II: Vector Calculus :

Vector algebra; Fields; Directional derivatives; normal derivative; Gradient; Divergence; Curl; Laplacian, Vector identities, Ordinary Integrals of Vectors, Multiple integrals, Jacobian, Notion of infinitesimal line, surface, volume elements; Line, surface, volume integrals of vector fields. Flux of a vector field, Gauss theorem, Green's theorem and Stokes Theorems, Orthogonal curvilinear coordinates; Calculation of divergence, gradient, curl and Laplacian in spherical polar and cylindrical coordinates. Multiple Integrals, Jacobian.

Unit III: Probability

Basic concepts: Sample space and probability, Permutation, combination, average and standard deviation; Binomial and Poisson distribution, Continuous random variable, Normal distribution

Unit IV: Complex Analysis :

Review of complex number; Graphical representation; Euler's formula; De-Moivre's theorem; Roots of complex numbers; Functions of complex variables; Multiple Valued Functions; Power Series; Analyticity; Cauchy-Riemann conditions; Singular functions; Poles, branch points, singularities; Simply and multiply connected region; Cauchy integral theorem; Cauchy integral formula; Cauchy's inequality; Derivative as integral; Morera's Theorem; Liouville's Theorem; Taylor and Laurent series; Residues; Contour Integration.

Reference Books:

1. Vector Analysis : Schaum Series
2. Advanced Engineering Mathematics : Kreyzig
3. Linear Algebra : Schaum Series
4. Complex Variable : Spiegel
5. Linear Vector Spaces : M. C. Jain

<u>**Semester III**</u>

Physics Practical **Lab III** **PHb-31L**

Optics

List of Experiments :

1. Focal length of two lenses by Nodal Slide method and verification of Newton's formula. (1)
2.
3. Determination of refractive Index and dispersive power of a prism using spectrometer. (2)
4. Determination of wavelength of LASER using plane transmission diffraction grating. (2)
5. Determination of wavelength of sodium light by Newton's Rings method. (4)
6. Determination of specific rotation of sugar solution by Laurent's Half-Shade Polarimeter(4)
7. Verification of Hartman's dispersion formula. (1)
8. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating. (2+2)
9. To determine dispersive power and resolving power of a plane diffraction grating.(1)
10. To determine the wavelength of Sodium light by using Fresnel’s Biprsm (1)

Semester III

Ability Enhancement Course **Instruments & Measurements** **PHB-31A**

Unit I: Basic Measurement Concepts :

Measurement systems – Static and dynamic characteristics – units and standards of Measurements, Error: different types, source of error, error analysis.

Unit II: Electrical Measurements :

DC measurements: dc voltmeter, ohmmeter, ammeter (analog and digital), And AC measurements: ac voltmeter, ammeter, wattmeter, energy meter (analog and digital). Digital multimeter, Digital frequency meter, ac bridges.

Unit III: Oscillators and Electronic Display:

Essentials of oscillators: Barkhauson criterion, RC phase shift oscillator, Wein Bridge oscillator, Hartley oscillator. The Cathode Ray Oscilloscope (CRO): Block diagram of a General Purpose Oscilloscope and its basic operation, Applications: Measurement of Time, Period and Frequency Types of CRO's: dual trace oscilloscope, digital storage oscilloscope. Signal generators, Function generators - RF signal generator.

Unit IV: Vacuum Systems & Gauges :

Fundamentals: Gas Flow Mechanisms, Concept of Throughput and pumping Speed. Different types of pump: Rotary and Diffusion Pump. Measurement of vacuum: gauges-pirani gauge, penning gauge.

Reference Books:

1. Electrical Measurements & Electronic Measurements : A.K. Sawhney
2. Modern electronic Instrumentation and measurement techniques : Helfrick Cooper
3. Electronic test instruments: analog and digital measurements: R. A. Witte
4. Instrumentation, devices and systems : Rangan, Sarma and Mani
5. Electronic Instrumentation : H. S. Kalsi .

Semester IV

Core Course **Electricity & Magnetism II** **PHB-41C**

Unit I: Current and circuits

Current density, steady and non-steady currents and continuity equation, rise and decay of currents in LR and CR circuits, Complex impedance and reactance, frequency response. Series and parallel circuits, resonance, Q factor, Power dissipation and power factor.

Unit II: Electrostatic fields in matter

Dielectrics, polarization and the electric displacement vector D. Susceptibility, permittivity, dielectric constant. Energy in dielectric systems, forces on Dielectrics, Clausius-Mossotti equation, Polar molecules. The Langevin formula.

Unit III: Magnetic fields in matter

Magnetization. Dia, para and ferromagnetism. The field of a magnetized object. Bound currents. Ampere's law in magnetized medium. Magnetic field intensity vector H. Magnetic susceptibility and permeability. Ferromagnetism. Energy loss in Hysteresis and the B-H curve.

Unit IV: Boundary value problems

Poisson's equation, Laplace's equation, boundary conditions, uniqueness theorem. Method of images, Different image problems; Boundary value problems with linear dielectric materials and linear magnetic materials.

Reference Books:

1. Introduction to Electrodynamics : D.J. Griffiths
2. Electricity and Magnetism : A.S. Mahajan and A.A. Rangwala
3. Electricity and Magnetism : Berkeley Physics Course ed. E.M. Purcell
4. Physics (Vol. 2) : Halliday and Resnick

Semester IV

Core Course **Quantum Mechanics** **PHB-42C**

Unit I: The Schrodinger equation

Schrodinger Equation. Conservation of Probability. Probability current density. Expectation values. Ehrenfest theorem. Time independent Schrodinger equation. Stationary States. Eigen function and eigenvalues.

Unit II: One dimensional problems

Particle in potential well - infinite square well and finite square wells. Potential barrier problems - step potential and rectangular potential. The harmonic oscillator problem.

Unit III: Operators and matrices

Hilbert space. Orthonormal bases. Linear operators. Dirac notation. Operators. Eigenvalues and eigenfunction of operators. Observables. Commutators. Generalised Uncertainty relations.

Unit IV: The three-dimensional problem

Spherically symmetric potential. Angular momentum operator and its eigenvalues. Commutation Relations. Spin of the electron. Hydrogen atom and the degeneracy of energy levels.

Reference

1. Concepts in Modern Physics: Beiser
2. Quantum Mechanics: Zettili
3. Quantum Mechanics: Griffiths
4. A text book on Quantum Mechanics : M.C.Jain

Semester IV

Core Course **Mathematical Physics II** **PHB-43C**

Unit I: Dirac Delta Function, Fourier Series and Transform:

Properties and representation of Dirac delta function in 1D, 2D, 3D; integral representation; Fourier series: Periodic functions; Dirichlet Conditions; Fourier coefficients; complex form, Expansion of arbitrary period function, non-periodic function, even and odd functions; Half range expansions; Summing of infinite series; Parseval Identity; Fourier Integral theorem, Fourier Transform, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem, Properties and Applications

Unit II: Differential Equations :

PDE's and ODE's; Separation of variables in different coordinates system; Normal form of FODE; Integrating factors; First and Second order linear differential equations; Superposition, Uniqueness, Wronskian; General solutions of homogeneous and inhomogeneous cases; Second order linear differential equation with constant coefficient; Central force problem;

Unit III: Special Functions:

Laplace's equation in Cartesian and spherical coordinates; Legendre's differential equation; series solution, orthogonality, recurrence and orthogonality relations; Expansions in Legendre polynomials; Laplace's equation in cylinderical coordinates; Bessel's differential equation; generating functions, recurrence relations etc; Expansions in Bessel's functions and examples; Some other PDE's of physics: Heat, wave and Schrodinger equations.

Unit IV: Tensors

Transformation properties of vectors, covariant and contra-variant vectors; Tensors: Definition, algebraic properties; Numerical tensors (Kronecker delta and Levi-Civita symbols), metric tensor, index raising, lowering, contraction; Electromagnetic field tensor; Covariant differential; Affine connection; Covariant derivative; metric connection; Riemann curvature tensor, Bianchiidentity; Ricci tensor; Einstein equation and curvature tensor.

Reference Books:

1. Mathematical Methods for Physicists: Arfken and Weber
2. Advanced Engineering Mathematics : Erwin Kreyszig
3. Fourier Analysis : M.R. Spiegel.
4. Differential Equations : G. Simmons.
5. Mathematical methods for Scientists & Engineers : D.A. McQuarrie.

<u>Semester IV</u>

Physics Practical **Lab IV** **PHB-41L**

Electricity & Magnetism

List of Experiments:

1. Determination of E.C.E. of copper using a Copper Voltameter and checking the accuracy of ammeter. (2)
2. Determination of Self Inductance of a coil using Anderson's Bridge. (3)
3. Determination Self Inductance of a coil by Owen’s Bridge.(2)
4. Study of LCR circuit and determination of impedence. (3)
5. Determination of magnetic field by Helmholtz coil. (2)
6. To draw the B-H curve for the iron and to determine the energy loss due to hysterisis.(2)
7. To determine the temperature coefficient of resistance by Platinum Resistance Thermometer (PRT). (2)
8. Conversion of a moving coil galvanometer into an ammeter and voltmeter.(3)
9. To determine the dielectric constants for solids.(1)
10. Study of the Wien bridge oscillator and determine the frequency of the oscillator. (2)

Semester IV

Choice Based Elective **Properties of Matter** **PHB-41E**

Unit I: Elasticity

Hooke's law, Relation between elastic constants, Torsion of a cylinder, Bending moment, Cantilever, Beam supported at both ends, Beams clamped at both ends, Reciprocity theorem, Elastic energy in different types of deformation, Rigidity modulus.

Unit II: Surface Tension

Surface Tension and Surface energy, Surface Tension determination by Jaeger's & Quincke's Methods, Angle of contact, Variation of surface tension with temperature, Excess of pressure over a curved surface, Shape of liquid drops, Application to spherical and cylindrical drops and bubbles.

Unit III: Viscosity

Streamlined and turbulent motion, Reynolds number, Poiseuille's formula, Determination of coefficient of viscosity, capillary flow method, Stoke's formula, viscosity of highly viscous liquids, Variation of viscosity of a liquid with temperature

Unit IV: Fluid Mechanics

Streamlines and flowlines - Equation of continuity- Euler's equation of motion- Bernoulli's theorem and its applications - Newtonian and non-Newtonian fluid

Reference Books:

1. General properties of Matter : Newman and Searle
2. Properties of Matter : Newman and Searle
3. Treatise on General Properties of matter : Newman and Searle

Semester V

Core Course **Electro Magnetic Theory** **PHB-51C**

Unit I: Electromagnetic Field Equations

Electromagnetic Units, Displacement current, Continuity Equation, Maxwell's Equations in vacuum and in media, Boundary conditions, Electromagnetic potentials, Conservation of energy.

Unit II: Multipole expansion and Radiation

Multipole Expansion of potentials. Radiation, Electric dipole field and radiation, Magnetic dipole radiation, Radiation from an arbitrary source.

Unit III: Propagation of Electromagnetic waves

Electromagnetic waves in vacuum and non conducting medium, Propagation in linear media, reflection and refraction at a plane interface, Brewster's angle, total internal reflection. EM waves in conductors, absorption and dispersion.

Unit IV: Waveguides

Cylindrical cavities and Waveguides, Wave guides, Modes in Rectangular wave guides, Energy flow and attenuation in Waveguides

Reference Books:

1. Introduction to Electrodynamics : D.J. Griffiths
2. Foundations of Electromagnetic Theory : Reitz, Millford and Christy
3. Classical Electrodynamics : J.D.Jackson
4. Introduction to Electromagnetic Field and Waves : Corson and Lorrain

Semester V

Core Course **Atomic & Molecular Physics** **PHB-52C**

Unit I: Introduction

Brief review of early models of atomic structure. Rutherford scattering, Limitation of Bohr-Sommerfeld theory. Frank & Hertz experiment. Addition of angular momenta.

Unit II: Atomic structure

Pauli's Exclusion Principle; Symmetric & Antisymmetric Wave Functions; Periodic table; Fine structure; Spin-orbit coupling; Vector model; L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms.

Unit III: Interaction with Electromagnetic field

Spin angular momentum; Larmors Theorem; Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman effect; Normal and Anomalous Zeeman Effect; Paschen Beck effect; Stark effect

Unit IV: Molecular Spectra

Rotational Energy levels, Selection rules and pure rotational spectra; Vibrational energy levels, selection rules and vibration spectra; Rotation-vibration energy levels, selection rules and spectra. Determination of internuclear distance. Raman Effect, Stoke's and Anti-Stoke's Lines.

Reference Books:

1. Concepts of Modern Physics : Arthur Beiser .
2. Introduction to Atomic Spectroscopy : H.E. White.
3. Modern Physics : Mani and Mehta
4. Physics of Atoms and Molecules : Bransden and Joachain.
5. Molecular Spectroscopy : C.N. Banwell.

Semester V

Core Course **Solid State Physics I** **PHB-53C**

Unit I: Crystal Structure Defects

Crystalline state of solids, Lattice Translation Vector, Unit cell, Wigner- Seitz cell, Number of lattice point per unit cell, packing fraction, Bravais lattice, Miller indices, Interplaner spacing, Symmetry elements, types of lattices Brillouin zone, reciprocal lattice. Point defects-Frenkel and Schottky vacancies, Line defects-Edge and screw dislocations, Planer defects, Stacking faults

Unit II: X-rays and Atomic Bonding

X-Rays: Continuous and characteristic X-rays spectra, Absorption of X-rays, Diffraction of X-rays, Bragg's law, Laue's equations, Powder method. Atomic Bonding: Interatomic forces and classification of solids, Bond dissociation Energy, Cohesive Energy of ionic crystal, Types of Bonds; Ionic bond, Covalent bond, Metallic Bonding, Van der Waals Bonding

Unit III: Elementary Lattice Dynamics

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic molecules chains, Acoustical and Optical Phonons, Qualitative Description of the Phonon spectrum in solids, Dulong and Petit law, Einstein and Debye theories of specific heat of solids, Debye T3 law.

Unit IV: Electrical Conductivity

Free electron theory, Sommerfeld model, Fermi level, Density of states, Electrical conductivity of metals and its temperature dependence, Weidemann-Franz law, Hall Effect.

Reference Books:

1. Introduction to Solid State Physics : Charles Kittle
2. Solid state physics : Rita John
3. Introduction to Solids : Azaroff L. V
4. Solid State Physics : N.W. Ashcroft and N.D. Mermin
5. Solid-state Physics : H. Ibach and H. Luth
6. Elements of Solid State Physics : J.P. Srivastava.

Semester V

Physics Practical **Lab V** **PHB-51L**

Modern Physics

List of Experiments :

1. Determination of Planck's constant by photocell and verify the radiation law. (2)
2. Determination of wavelength of Sodium light using Michelson's Interferometer (2)
3. Determination of the band gap of a semiconductor using four probe method. (2)
4. Determination of magnetic susceptiblity of $MnCl_2$ by Quinck's method (2)
5. Determination of Planck's constant by cut off method. (2)
6. e/m by Thomson's method. (2)
7. To determine the Hall coefficient of a semiconductor sample.(2)
8. To demonstrate the concept of quantisation of energy levels using Franck Hertz Experiment (1)
9. To determine the ionization potential of mercury (1)
10. To determine the Zeeman splitting with Mercury. (1)

Semester V

Choice Based Elective | **Classical Mechanics** | **PHB-51E**

Unit I: Lagrangian formulation

Generalised coordinates, constraints and degrees of freedom; D'Alembart's principle; Lagrange's equation for conservative systems and its application to simple cases

Unit II: Hamiltonian formulation

Calculus of Variation, Hamilton's principle, Definition of Hamiltonian; Generalised momentum; Cyclic coordinates and laws; Hamilton's equation and its application to simple cases.

Unit III: Special Theory of Relativity - II

Lorentz transformation; Four vectors; Example of common four-vectors; Relativistic dynamics: variation of mass with velocity; Energy momentum relationship; Space-time diagram; Space like, time-like and light like intervals; Light cone.

Unit IV: Central force problem

Motion under central force; Two body central force problem, reduction to the equivalent one body problem; Nature of orbits in an attractive inverse square field; Kepler's laws of planetary motion; Condition for stable circular orbit.

Reference Books:

1.Classical Mechanics: H. Goldstein.
2.Mechanics: L. D. Landau and E. M. Lifshitz
3.Introduction to Classical Mechanics: Takwale and Puranik.
4.Theoretical Mechanics: Murray Spiegel.

Semester VI

Core Course **Solid State Physics II** **PHB-61C**

Unit I: Elementary Band Theory of Solids

Bloch Theorem, Electron in periodic field: Kronig Penney model, Brillouin zones, Effective mass of electron, Origin of Band Gap, Insulator, semiconductor and metals. Intrinsic and Extrinsic Semiconductors, Carrier concentration, Fermi level and conductivity for Intrinsic and Extrinsic Semiconductors

Unit II: Magnetic Properties of Matter

Response of substance to magnetic fields, Dia, Para and Ferromagnetic materials, Absence of magnetic charge, Electric current in atoms, Electron spin and magnetic moment Measurement of the susceptibility of paramagnetic substances, Langevin's theory of diamagnetic and paramagnetic substances, Curie- Weiss Law, Theory of ferromagnetism.

Unit III: Dielectric Properties of Solids

Polarization and Susceptibility, The local field, Dielectric Constant and Polarizability, Clausius-Mossitti Equation, Sources of Polarizability (Electronic, Ionic, Dipolar Polari ability), Classical Theory of Electronic Polari ability, Frequency Dependence of Total Polarizability.

Unit IV: Superconductivity

Introduction and Historical Developments, Electrical Resistivity, Perfect Diamagnetism or Meissner Effect, Supercurrents and Penetration Depth, London Equations, Critical Field and Critical Temperature, Type I and Type II Superconductors, Thermodynamical properties, Flux Quantization, The Josephson Effects and Tunnelling, Idea of the BCS Theory, High Temperature Ceramic Superconductors.

Reference Books:

1. Introduction to Solid State Physics : Charles Kittle
2. Solid state physics : Rita John
3. Introduction to Solids : Azaroff L. V
4. Solid State Physics : N.W. Ashcroft and N.D. Mermin
5. Solid-state Physics : H. Ibach and H. Luth
6. Elements of Solid State Physics : J.P. Srivastava.
7. Solid State Physics : M.A.Wahab

<u>Semester VI</u>

Core Course **Nuclear &Particle Physics** **PHB-62C**

Unit I: Radioactivity

Radioactive decay constant, half life and mean life. Radioactive transformations and equilibrium. Natural radioactive series. Alpha decay. Gamow's theory. Beta decay. Pauli's neutrino hypothesis. Electron capture process.

Unit II: Nuclear models and reactions

The liquid drop model of a nucleus. Weizsacker's semi-empirical mass formula. The shell model of a nucleus Nuclear reactions. Threshold energy. Energy production in stars by proton- proton and carbon cycle.

Unit III: Elementary Particles

Fundamental interactions in nature. Classification of elementary particles. Photons, leptons, mesons and baryons. Quantum numbers: isospin, strangeness, and charm. Quarks and confinement. Conservation laws.

Unit IV: Accelerators and Detectors

Need of accelerators. Cyclotron. Betatron and Linac. Detectors for charged particles. Working principle of Cloud chamber, Bubble chamber, Ionisation chamber. Proportional counter. G.M. Counter. Scintillation Counter.

Reference Book

1. Concepts of Modem Physics : A. Beiser
2. Nuclear Physics : I. Kaplan
3. Concepts of Nuclear Physics : Cohen
4. Introduction to the Physics of Nuclei and Particles : Dunlap
5. Introductory Nuclear Physics : Krane

<u>Semester VI</u>

Core Course **Statistical Mechanics** **PHB-63C**

Unit I: Foundations of Statistics

The macroscopic and the microscopic states, phase space, trajectories and density of states, Liouville's theorem, ensemble theory, the principle of maximum entropy, contact between statistical mechanics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox

Unit II: Ensemble Theory

Micro-canonical ensemble; Canonical Ensemble, partition function, calculation of statistical quantities, Energy fluctuations. Particle number fluctuation, Grand canonical ensemble, Entropy in grand canonical ensemble, thermodynamic potentials.

Unit III: Quantum Statistics

Statistics of indistinguishable particles, Maxwell-Boltzmann distribution, Need for quantum statistics, Postulates of quantum statistics, density matrix, statistics of ensembles.

Unit IV: Bose-Einstein and Fermi-Dirac Statistics

Bose-Einstein distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, Photons, Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal.

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Reference Books:

1. Fundamentals of Statistical and Thermal Physics : F. Reif
2. Thermodynamics and an Introduction to Thermostatistics : H. B. Callen
3. Thermodynamics and Statistical Mechanics : Greiner, Neiser and Stocker

Semester VI

Skill Enhancement Course **Computational Methods in Physics** **PHB-61AL**

Unit I: Introduction

Introduction to operating system, Use of linux as an OS, Algorithm: definition, properties and development; Flowchart: Concept of flowchart, symbols, guidelines, types. Some examples.

Unit II: Scientific Programming and Logic

Introduction to FORTRAN, Basic elements of FORTRAN, I/O Statements (unformatted/formatted), Layout of Fortran Program, Format of writing Program and concept of coding; Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements Subscripted Variables, Functions and Subroutines.

Unit III: Visualization

Importance of visualization of computation and computational data, Introduction to Gnuplot; Basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Unit IV: Hands on Exercise

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization .

Reference Books:

1. Introduction to Numerical Analysis : S.S. Sastry
2. Computer Programming in Fortran 77 : V. Rajaraman
3. Schaum's Outline of Theory and Problems of Programming with Fortran :S.Lipsdutz and A Poe.

<u>Semester VI</u>

Physics Practical **Lab VI** **PHB-61L**

Advanced Electronics

List of Experiments :

1. To design an inverting amplifier of given gain using Op-amp (741,351) and study the frequency response
2. To design non-inverting amplifier of given gain using Op-amp (741,351) and study its frequency response
3. To design and study an Op-amp adder
4. To design and study the use of an op-amp as an Integrator / Differentiator.
5. To determine the frequency and duty cycle of an astable 555 timer.
6. To design an astable multivibrator of frequency 1 kHz using a 555 timer.
7. To design a monostable 555 multivibrator and measure the pulsewidth of its output.
8. To verify and design AND, OR, NOT and XOR gates using NAND gates.
9. To design a Half Adder and Full Adder circuit using IC.
10. To construct Flip-Flop circuits(RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs

DEPARTMENT OF PHYSICS
JAMIA MILLIA ISLAMIA, NEW DELHI

Jamia Millia Islamia, a Central University, was founded at Aligarh in 1920 during the Khilafat and Non-Cooperation Movements in response to Gandhiji's call to boycott government supported educational institutions. The Jamia moved from Aligarh to Delhi in 1925. Since then, it has been continuously growing, always improving its methods, and branching out from time to time to meet new needs. Jamia Millia Islamia was made a Central University in 1988.

The Department of Physics was created in 1971. The strength of the faculty in the Department, at present, is 20.

The Department offers a 2 year (4 semesters) postgraduate course M.Sc. (Physics) with the following three specializations : (i) Materials Science; (ii) Lasers and Spectroscopy; and (iii) Theoretical Physics. For the M.Sc. Course in Physics, 35 students are admitted every year.

The Department also has a full-fledged Ph.D. Program as part of the ongoing research.

DEPARTMENT OF PHYSICS
JAMIA MILLIA ISLAMIA, NEW DELHI
M.Sc. Physics

Paper Code	Topic	M.Marks	Periods per week	Credits
	Semester I			
PHM101	Classical Mechanics	100	L 3 T 1 P 0	4
PHM102	Quantum Mechanics I	100	L 3 T 1 P 0	4
PHM103	Mathematical Physics	100	L 3 T 1 P 0	4
PHM104	Electronics	100	L 3 T 1 P 0	4
PHM105	Lab. I	150	L 0 T 0 P 12	6
	Semester II			
PHM201	Condensed Matter Physics I	100	L 3 T 1 P 0	4
PHM202	Quantum Mechanics II	100	L 3 T 1 P 0	4
PHM203	Electrodynamics	100	L 3 T 1 P 0	4
PHM204	Numerical Methods & Computer Lab.	100	L 2 T 0 P 4	4
PHM205	Lab. II	150	L 0 T 0 P 12	6
	Semester III			
PHM301	Atomic and Molecular Physics	100	L 3 T 1 P 0	4
PHM302	Nuclear and Particle Physics	100	L 3 T 1 P 0	4
PHM303	Condensed Matter Physics II	100	L 3 T 1 P 0	4
PHM304	Spl. paper I	100	L 3 T 1 P 0	4
PHM305	Lab. III	100	L 0 T 0 P 8	4
	Semester IV			
PHM401	Statistical Mechanics	100	L 3 T 1 P 0	4
PHM402	Spl. paper II	100	L 3 T 1 P 0	4
PHM403	Spl. paper III	100	L 3 T 1 P 0	4
PHM404	Spl. paper IV	100	L 3 T 1 P 0	4
PHM405	Project	200	L 0 T 8 P 0	8

SPECIALIZATIONS		
Materials Science	**Laser & Spectroscopy**	**Theoretical Physics**
PHM304M Physics of Novel Materials	PHM304L Laser Physics	PHM304T Advanced Mathematical Physics
PHM402M Growth & imperfections of Materials	PHM402L Photonics	PHM402T General Relativity
PHM403M Characterization of Materials	PHM403L Quantum Optics	PHM403T Particle Physics
PHM404M Physics & Technology of Semiconductor Devices	PHM404L Laser Spectroscopy	PHM404T Quantum Field Theory

CLASSICAL MECHANICS

Code PHM101 **Max. Marks 100**

UNIT 1 : Newtonian mechanics and its limitations. Constrained motion. Constraints and their classification. Principle of virtual work. D' Alembert's principle. Generalised coordinates. Deduction of Lagrange's equations from D' Alembert's Principle. Generalised momenta and energy. Cyclic or ignorable coordinates. Rayleigh' s dissipation function. Integrals of motion. Symmetries of space and time with conservation laws. (8 lectures)

UNIT 2 : Central force. Definition and properties of central force. Two-body central force problem. Stability of orbits. Conditions for closure. General analysis of orbits. Kepler's laws. Kepler's equation. Artificial satellites. Rutherford scattering. (10 lectures)

UNIT 3 : Principle of least action. Hamilton's principle. The calculas of variations. Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle. Hamilton's principle and characteristic functions. (8 lectures)

UNIT 4 : Canonical Transformations. Generating functions. Poisson bracket. Poisson's Theorem. Invariance of PB under canonical transformations. Angular momentum PBs. Hamilton-Jacobi equation. Connection with canonical transformation. Problems. (12 lectures)

UNIT 5 : Small Oscillations. Normal modes and coordinates. Problems. (6 lectures)

REFERENCES

1. Classical Mechanics by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991)
2. Classical Mechanics by H. Goldstein (Addison Wesley, 2000)

QUANTUM MECHANICS I

Code PHM102 **Max. Marks 100**

UNIT 1 : Mathematical tools Brief introduction to origins of quantum Physics. Wave packets. Dirac notation. Operators, their eigenvalues and eigenfunctions, orthonormality, completeness and closure. Generalized Uncertainty Principle. Unitary transformations, change of basis. Matrix Representation of operators. Continuous basis, position and momentum representation and their connection. Parity operator. (15 lectures)

UNIT 2 : Fundamental Concepts of Quantum Mechanics Basic postulates of quantum mechanics. Measurement. Time evolution of system's state. Discrete and continuous spetra in 1-D. Solution of 1-D harmonic oscillator using matrix mechanics. (12 lectures)

UNIT 3 : Angular Momentum Orbital, Spin and total angular momentum operators. Pauli spin matrices, their Commutation relations. Eigenvalues and eigenfunctions of L2 and Lz. (10 lectures)

UNIT 4 : Identical Particles Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The pauli exclusion principle. (8 lectures)

REFERENCES

1. Franz Schwabl : Quantum Mechanics
2. J. J. Sakurai : Modern Quantum Mechanics
3. N. Zettili : Quantum Mechanics
4. P. A. M. Dirac : Priciples of Quantum Mechanics
5. Bohm : Quantum Mechanics

MATHEMATICAL PHYSICS

Code PHM103 **Max. Marks 100**

UNIT 1 : Review of Basic Methods Real and complex numbers; Euclidean space; Differentiability; Series and convergence. Function of a complex variable; Analytic functions; Cauchy's theorem; calculus of residues and applications. Advanced vector calculus; multiple integrals. (10 lectures)

UNIT 2 : Linear Differential Equations & Special Functions Series solutions of ordinary differential equations; ordinary, regular and irregular singular points; Gamma function; Special functions (Legendre, Bessel, Laguerre, Hermite); Hypergeometric and confluent hypergeometric functions. (12 lectures)

UNIT 3 : Partial Differential Equations and Green Function Method Classification of PDE's and boundary conditions; method of separation of variables; Green function method for Laplace, Poisson, wave, Klein-Gordon and heat equations; solutions of boundary value problems using Fourier series and Bessel functions. (10 lectures)

UNIT 4 : Elements of Group Theory Definitions and examples of a group; subgroup, cosets, conjugate classes, invariant subgroups and factor group; isomorphism and homomorphism; Permutation groups; Representations of a group, Reducible and irreducible representations, orthogonality relations; Topological groups and Lie groups, SO(2), SO(3), Lorentz group, Generators of U(n) and SU(n), SU(2), SU(3). (8 lectures)

UNIT 5 : Integral Equations Homogeneous and Inhomogeneous equations, Method of successive approximations, Hilbert-Schmidt method. (5 lectures)

REFERENCES

1.Mathews and Walker, Mathematical Methods of Physics, Addison Wesley Publishing.
2.G B Arfken, Mathematical Methods for Physicists, Academic Press.
3.S Hassani, Mathematical Physics, Springer-Verlag, New York.
4.P Dennery & A Krzywicki, Mathematics for Physicists, Dover Publications, New York.
5.M Hammermash, Group Theory and its Applications to Physical Problems.
6.R Courant and D Hilbert, Methods of Mathematical Physics, Vol I & II.
7.Morse and Feshback, Mathematical Physics, Vol I & II.

ELECTRONICS

Code PHM104 **Max. Marks 100**

UNIT 1 : Semiconductor Devices I Semiconducting Materials, conduction in semiconductors, Charge densities in a semiconductors, PN junction, space charge and electric field distribution at junctions, forward and reverse biased conditions, Space charge capacitance, varactor diode, Zener and avalanche breakdowns, zener diodes, Schottky barrier, tunnel diode, photodiode, LED, p-n-p-n devices and their characteristics, SCR. (16 Lectures)

UNIT 2 : Semiconductor Devices II Transistors: Bipolar junction Transistor (BJT), Ebers Moll Model, Analysis of CE amplifier using h-parameters, The T-network equivalent circuit, constants of CB and CE amplifier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field-Effect Transistors (FET) and MOSFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions. (16 Lectures)

UNIT 3 : Feedback Principle Negative feedback, effect of negative feedback on input/output resistances and voltage gain, gain stabilization, effect of negative feedback on band width, voltage series feedback, voltage shunt feedback applied to BJT. (6 Lectures)

UNIT 4 : Microwave Electronics Microwaves, Principle of velocity modulation and bunching of electrons, Basic principles of two cavity klystrons and Reflex Klystrons, operation of magnetrons, characteristics of microwave diode. (7 Lectures)

REFERENCES

1. John D. Ryder, Electronic Fundamentals and Applications.
2. Millman and Halkins; Electronic Devices and Circuits
3. Ben G. Streetman : Solid State Electronic Devices
4. Ramabhadran S. Electronics
5. Boylested and Nashelsky; Electronics Devices and Circuit theory
6. Millman J. and Taub, H; Pulse, Digital and Switching Waveforms
7. S.W. Amos; Fundamental of Transistor
8. W.J. Reich; Microwave Principle.
9. K.L. Gupta; Microwaves
10. G.J.Wheeler; Introduction to Microwave.
11. S.M. Sze; Semiconductor Devices- Physics and Tecnology.

PHYSICS LAB I

Code PHM105 **Max. Marks 150**

LIST OF EXPERIMENTS

1. Design & Study of Common Emitter Amplifier
2. Study of Operational Amplifier IC-741 : summer, inverting/non-inverting amplifier, differentiator, integrator
3. Active filters using op-amp
4. Study of IC - 555 as astable, monostable and bistable multivibrator
5. UJT - characteristics and it's applications as relaxation oscillator
6. SCR - characteristics and it's applications as switching device
7. Study of Optoelectronic Devices
8. Study of Phase Shift Oscillator
9. Study of Negative & Positive Feedback Amplifier
10. FET - I/V characteristics, biasing and it's application as an amplifier
11. MOSFET - I/V characteristics, biasing and it's application as an amplifier
12. Study of Pulse Amplitude Modulation (PAM) & Demodulation
13. A/D and D/A converter
14. Design & study of regulated and stabilized power supply.
15. Design & study of triangular wave generator.

CONDENSED MATTER PHYSICS I

<u>**Code PHM201**</u> <u>**Max. Marks 100**</u>

UNIT 1 : Bonding in crystals: covalent, ionic, metallic, hydrogen bond, van der Waal's bond and the Madelung constant. Crystalline solids, unit cell, primitive cell, Bravais lattices, Miller indices, closed packed structures. Atomic radius, lattice constant and density. Connection between orbital symmetry and crystal structure. Scattering from periodic structures, reciprocal lattice, Brillouin Zones.

UNIT 2 : Free electrons in solids, density of states, Fermi surface, Fermi gas at T=0 K, Fermi statistics, specific heat capacity of electrons in metals, thermionic emission of electrons from metals.

UNIT 3 : Electronic band structure in solids, Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model : density of states, examples of band structures. Fermi surfaces of metals and semiconductors. (12 lectures)

UNIT 4 : Transport properties: Motion of electrons in bands and the effective mass, currents in bands and holes, scattering of electrons in bands, Boltzman equation and relaxation time, electrical conductivity of metals, thermoelectric effects, the Wiedemann-Franz Law. (11 lectures)

UNIT 5 : Lattice dynamics of atoms in crystals, vibrations of monoatomic and diatomic linear chains, acoustic and optical phonon modes, density of states, thermal properties of crystal lattices, thermal energy of the harmonic oscillator, specific heat capacity of the lattice, Debye theory of specific heats. (11 lectures)

<u>**REFERENCES**</u>

1. Hook and Hall : Solid State Physics
2. Kittel : Introduction to Solid State Physics
3. Ibach and Luth : Solid State Physics
4. H. M. Rosenberg : Introduction to the Theory of Solids
5. Blakemore : Solid State Physics
6. Ashcroft and Mermin : Solid State Physics

QUANTUM MECHANICS II

Code PHM202 **Max. Marks 100**

UNIT 1 : Approximation methods for stationary systems Time independent perturbation theory. Perturbation of non-degenerate states: first and second order perturbation. Perturbation of a harmonic osscilator. Perturbation of degenerate states, removal of degeneracy. Zeeman and Stark effects. Variational and WKB methods. (9 lectures)

UNIT 2 : Approximation methods for non-stationary systems Scroedinger, Heisenberg and interaction pictures, Equations of Motion. Constatnt and harmonic perturbation. Discrete and continuous case, transition probability. Fermi golden rule. Adiabatic and sudden approximations. (8 lectures)

UNIT 3 : Scattering Theory Scattering of a wave packet. The differential and total Cross section. The Born approximation. Partial waves and phase shifts. The Lippman Schwinger equation. Definition and properties of S-matrix, T matrix. Optical theorem. (10 lectures)

UNIT 4 : Relativistic Quantum Mechanics Klein-Gordon and Dirac equations, properties of Dirac matrices. Lorentz and CPT invariance of Dirac equation. Non-relativistic reduction of the Dirac equation. Central forces and the hydrogen atom. (8 lectures)

UNIT 5 : Solutions to Dirac equation Free particle solution, hydrogen atom in dirac's theory, Dirac electron in constant magnetic field, Foldy-Wouthuysen transformation, Hole theory. (8 lectures)

REFERENCES

1. Franz Schwabl : Quantum Mechanics
2. Eugen Merzbacher : Quantum Mechanics
3. N. Zettili : Quantum Mechanics
4. P. M. Mathews and K. Venkatesan: Quantum Mechanics
5. P. A. M. Dirac : Priciples of Quantum Mechanics

ELECTRODYNAMICS

Code PHM203 **Max. Marks 100**

UNIT 1 : Maxwells equations. Continuity Equation. Lorentz force. Poynting theorem. Conservation of energy and momentum. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauge.

UNIT 2 : Generalized functions. Grenn's functions for Poisson, Helmholtz and Wave equations. Retarded and Advenced solutions for Maxwell's equations. Jefimencko formulas for fields for charge and current distriubutions. Lienard-Wiechert Potentials. Electromagnetic field of a moving point charge. Feynman formulas.

UNIT 3 : Review of Special Theory of Relativity. Lorentz transformations. Energy and momentum. Covariant formulation of electrodynamics. Transformation of electromagnetic fields. Lorentz group. Infinitesimal generators. Lie algebra of Lorentz group. Action Principle. Stess-energy tensor.

UNIT 4 : Equations of motion of a point charge in electromagnetic fields. Radiations emitted by an accelerated charge. Energy radiation formula and radiative reaction.

REFERENCES

1. Classical Electrodynamics : J.D.Jackson, III Ed. 1999.
2. Classical Theorey of Fields : Landau & Lifshitz
3. Introduction to Electrodynamics: D. J. Griffiths
4. Feynman Lectures on Physics : Vol II
5. Foundations of Electromagnetic Theorey : Reitz, Milford and Christy
6. Classical Charged Particle : Rohrlich

NUMERICAL METHODS & COMPUTER LAB

Code PHM204 **Max. Marks 100**

UNIT 1 : Introduction to operating systems, computer programming (FORTRAN and/or C, C++) and graphics (gnuplot, xmgrace etc.).

UNIT 2 : Summation of finite and infinite series, root finding techniques (bisection, secant, Newton-Raphson methods), Sorting, interpolation, extrapolation, regression, modelling of data (least square fit etc.).

UNIT 3 : Matrices (addition, multiplication, eigenvalues, eigenvectors, inversion, diagonalization, solution of simultaneous equations).

UNIT 4 : Numerical integration (trapezoidal, Simpson, Gauss quadrature etc.).

UNIT 5 : Solution of differential equations (Euler and RK methods).

UNIT 6 : Simulation techniques (Monte Carlo, Molecular Dynamics, Ising model, percolation, cellular automata, Diffusion limited aggregation), fractals and nonlinear dynamics.

REFERENCES

1. V. Rajaraman, Computer Programming in Fortran 77.
2. V. Rajaraman, Computer Programming in Fortran 90/95.

PHYSICS LAB II

Code PHM 205 **Max. Marks 150**

LIST OF EXPERIMENTS

1. G.M. Tube Characteristics & Absorption Coefficient
2. Nuclear exp.
3. Study of high energy interaction in nuclear emulsion
4. Study of Hall effect in semiconductors:
(a) Determination of Hall voltage and Hall coefficient, and
(b) Determination of the mobility of charge carriers and the carrier concentration.
5. Study of Magnetic Susceptibility of $MnCl_2$
6. Study of Fourier Analyser
7. To determine dissociation Energy of Iodine Molecule
8. To determine the Ionisation Potential of Argon with the help of Frank Hertz Tube
9. To study of Hysteresis loop curve of Magnetic Materials
10. To study Magnetoresistance of Semiconductor
11. To study conductivity of a Semiconductor using Four Probe method
12. Determination of the energy gap of a semiconductor by four probe method.
13. To determine the response of silicon solar cells and the effect of prolonged irradiation, and to calculate the efficiency and fill factors of a variety of solar cells.
14. To determine :
a. the velocity of ultrasonic waves in a liquid and,
b. the compressibility of the liquid.
15. Study of electron spin resonance (ESR) spectrum of a paramagnetic substance.

ATOMIC AND MOLECULAR PHYSICS

Code PHM301 **Max. Marks 100**

UNIT 1: Review of Solution of Schroedinger's equation for Coulomb field and Hydrogen atom, dipole approximation, spectroscopic terms and selection rules, intensities of spectral lines. (8 lectures)

UNIT 2: Fine structure of Hydrogen like atoms: spin-orbit interaction, relativistic correction, Lamb shift. Interaction with external fields: Zeeman, Paschen-Back and Stark effects. (12 lectures)

UNIT 3: The LS-coupling approximation, J-J coupling, hyperfine structures. The central field approximation: the central field, Thomas Fermi-potential, alkali atom spectra, Na doublet. (10 lectures)

UNIT 4: Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational-Vibrational and Electronic spectra of Di-atomic molecules, Selection rules, Frank-Condon principle, Raman spectra, NMR, ESR. (10 lectures)

UNIT 5: Lasers : Spontaneous and stimulated emission, optical pumping, population inversion, rate equations, properties of laser beams: temporal and spatial coherence, simple description of Ammonia maser, $C0_2$ and He-Ne lasers. (5 lectures)

REFERENCES

1. B.H. Bransden & C.J. Joachain : Physics of Atoms and Molecules
2. G.K. Woodgate : Elementary Atomic Structure, Mc Graw-Hill
3. H.S. Mani & G.K. Mehta : Introduction to Modem Physics, East West Press
4. G. Herzberg : Molecular Spectra
5. C.N. Banwell : Fundamentals of Molecular Spectroscopy.
6. W. Demtroder : Laser Spectroscopy
7. O. Svelto : Principle of Lasers
8. K. Shimoda : Introduction to Laser Physics

NUCLEAR AND PARTICLE PHYSICS

Code PHM302 **Max. Marks 100**

UNIT 1 : Basic Nuclear Concepts Mass, Charge, and Constituents of the nucleus, Nuclear size and distribution of nucleons, Energies of nucleons in the nucleus, Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei. (5 Lectures)

UNIT 2 : Nuclear Forces Characteristics of nuclear forces -Range and strength, Simple theory of two nucleon system -deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces. (7 Lectures)

UNIT 3 : Experimental Methods of Nuclear & Particle Physics Interaction of charged particles with matter. Stopping power and range. Detectors for energetic charged particles; Solid State or Semiconductor detector. (8 Lectures)

UNIT 4 : Particle Accelerators Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; Alternating gradient accelerator, Colliding beam accelerator. (5 Lectures)

UNIT 5 : Elementary particles Classification and properties of elementary particles -Leptons, Baryons, mesons particles and antiparticles excited states and resonances. Various types of interactions gravitational, electromagnetic, weak and strong interactions and their mediating quanta, Conservation rules in fundamental interactions. Charge symmetry and charge independence, Parity and charge conjugation, Conservation of parity and its violation in different types of interactions. Strange particles, associated production, strangeness and decay modes of charged Kaons, Isospin and its conservation. Idea of eight fold way and quarks. (20 Lectures)

REFERENCES

1. Segre : Nuclei and Particles
2. Cohen : Nuclear Physics
3. Enge : Nuclear Physics
4. Marmur and Sheldon : Physics of Nuclei and Particles

CONDENSED MATTER PHYSICS II

Code PHM303 **Max. Marks 100**

UNIT 1 : Review of free electron theory, nearly free electron approximation, Wannier functions, LCAO approximation, effective mass tensor, Dielectric constant of metals and insulators. (08 Lectures)

UNIT 2 : Optical properties of materials, optical constants-Kramers-kronig relations, polarons, excitons. Electronic interband and intraband transitions, relation between optical properties and band structure, reflectance, diffraction, dispersion, photoluminescence, electroluminescence. Hartree-Fock approximation, screening, plasmons. (10 lectures)

UNIT 3 : Magnetism: Diamagnetism (including Landau diamagnetism) and Paramagnetism including van Vleck and Langevin paramagnetism), Exchange interaction of free electrons, Band model of Ferromagnetism, superexchange, double exchange, Hubbard model, Antiferromagnetism, Neel temperature, spin-waves, 2D electron gas in a magnetic field :Quantum Hall Effect. Landau levels. Degeneracy. Fractional quantum Hall effect. (15 lectures)

UNIT 4 : Fundamental phenomena of superconductivity, Meissner effect, London euation, Type I and type II superconductors. Ginzburg-Landau Theory, Coopers pairing and BCS theory. BCS wavefunctions, Josephson Effect, SQUIDS. Weakly interacting Bose gas, Superfluidity. (12 lectures).

REFERENCES

1. O. Madelung: Introduction to Solid State Theory
2. Ibach and Luth : Solid State Physics
3. Ashcroft and Mermin : Solid State Physics
4. Kittel : Introduction to Solid State Physics
5. C. Kittel: Quantum Theory of Solid.

PHYSICS OF NOVEL MATERIALS

Code PHM304M **Max. Marks 100**

UNIT 1 : Quantum Well Structures: electron confinement in infinitely deep square well, confinement in one and two dimensional well, idea of a quantum well structure, quantum dots, quantum wires. (10 lectures)

UNIT 2 : Carbon nanotubes: carbon nanotubes and other carbon materials, bonding between carbon atoms, single and multiwalled nanotube growth and characterization, electronic structure, crsytal structure, junctions and defects of nanotubes. Electronic structure, transport, optical properties, thermal and mechanical properties of nanotubes. Electron spectroscopy and scanning probe microscopy of nanotubes. Applications of carbon nanotubes. (15 lectures)

UNIT 3 : Non-carbon nanostructures : semiconductor heterostructures, synthesis of nanomaterials using chemical techniques. (10 lectures)

UNIT 4 : MEMS (microelectromechanical systems) and NEMS (nanoelectromechanical systems), nanomachines and applications. (10 lectures)

REFERENCES

1. D. Bimberg, M.Grundman, N.N. Ledentsov: Quantum Dot Heterostructures
2. M.S. Dresselhaus, G. Dresselhaus, Ph.Avouris: Carbon Nanotubes: Synthesis,Structure, Properties and Applications
3. Mott and Davis: Electronics in Non-crystalline materials
4. Elliot: Physics of Amorphous materials
5. A. V. Narlikar : Superconductivity
6. O. Madelung : Introduction to Solid State Theory

LASER PHYSICS & SPECTROSCOPY

Code PHM304L **Max. Marks 100**

UNIT 1 : Stimulated Absorption, Stimulated Emission and spontaneous Emission : Absorption and Gain Coefficient. Radiative Lifetime and Spontaneous Transition Probabilities. Saturation: Saturation of Absorption. Gain Saturation. Widths and Profiles of Spectral Lines: Homogeneous and Inhomogeneous Broadening. Natural Linewidth. Doppler Width. Collision Broadening of Spectral Lines. (8 Lectures)

UNIT 2 : Basic principles of LASERS Laser Amplification. Laser Oscillation. Optical and Electrical Pumping. Optical Resonators. Optimization of Favourable Losses in Resonators. Resonance Frequencies of Optical Resonators. Laser Modes. Rate Equations for Three-Level and Four-Level Lasers. Steady State Output. CW and Transient Laser Behaviour. Single-Mode Operation. Q-Switching. Mode Locking. (15 Lectures)

UNIT 3 : LASER systems and their applications Types of Lasers. Solis State lasers, Gas Lasers, Dye Lasers, Semiconductor Lasers, Excimer Lasers. Applications of Lasers. (8 lectures)

UNIT 4 : Doppler limited Absorption and Fluorescence Spectroscopy with lasers- Sensitive methods of Absorption Spectroscopy: Intracavity Absorption, CRDS, Fluorescence Excitation Spectroscopy and LIF, Ionization Spectroscopy. Non- linear Spectroscopy. Saturation Spectroscopy, Polarization Spectroscopy, Multiphoton Spectroscopy. Doppler- Free Techniques in Spectroscopy. Laser Raman Spectroscopy: Non-linear Raman Spectroscopy, CARS, Resonant CARS. Time-Resolved Laser Spectroscopy. (15 lectures)

REFERENCES

1. K.Shimoda : Introduction to Laser Physics; (Springer-Verlag)
2. O. Svelto : Principles of Lasers (plenum Press)
3. D.C. OShea, W.R. Callen & W.T. Rhodes. Introduction to Lasers and their Applications (Addison-Wesley)
4. W Demtrder. Laser Spectroscopy A Basic Concepts and Instrumentation (SpringerVerlag)
5. A. Corney : Atomic and Laser Spectroscopy (Clarendon Press)
6. Thyagarajan and Ghatak : Lasers- Theory and Applications

ADVANCED MATHEMATICAL PHYSICS

Code PHM304T **Max. Marks 100**

UNIT 1: Group and representations Definitions and examples of group, Useful theorems, Subgroups, Schur's lemma, Conjugate classes, Invariant subgroups, Factor groups, Homomorphism, Direct Products, Permutation group, Young tableaux, reducible and irreducible representations, Rotation(O(2) and O(3)) groups, Poincare (O(1,3)) group. (10 lectures)

UNIT 2: Lie groups I Generators, Lie algebras, Jacobi identity , adjoint representation, Simple algebras and groups, Tensor operators, Wigner- Eckart theorem, SU(2) and SU(3) groups, roots and Weights, Simple roots, Dynkin diagrams, Cartan matrix. (8 lectures)

UNIT 3: Differential Geometry Metric Spaces, Introduction to general topolog: Topological spaces, some example of topologies on a finite set, Compact spaces, homeomorphism, Differentiable Manifolds: Main definitions, Tangent Spaces, Vector Fields, Integral Curves and Flows, Cotangent Vectos, General Tensors and n- forms, DeRham Cohomology. (10 lectures)

UNIT 4: Fiber Bundles Bundles in general: Definition, idea of a cross-section,pullback operation, Universal bundles, Principal Fibre bundles,Vector bundles, Connections in a bundles, Parallel Transport.(9 lectures)

UNIT 5: Lie Groups II Basic ideas,Lie Algebra of a Lie group, Left- Invariat Forms, Transfomation Groups, Infinitesimal Transfomations. (8 lectures)

REFERENCES

1. Lie Algebra in Particle Physics. Howard Georgi, ABP.
2. Modern Differential Geometry for Physicists. Chris J Isham, WS
3. An Introduction to Differential Geometry. T.J Willmore,OUP.
4. Geometry, Topology and Physics. M. Nakahara. Adam Hilger, Bristol.
5. Lie Groups, Lie Algebras and Some of their Applications. R.Gilmore, John Wiley.

PHYSICS LAB III

Code PHM305 **Max. Marks 150**

LIST OF EXPERIMENTS

1. Microwave Diffraction/interference/polarization
2. Fuel Cell
3. Experiments with Phoenix kit
4. e/m by Thompson's method
5. Hydrogen spectrum
6. He spectrum
7. Determination of elastic constants by ultrasonics using Pizo Electric Crystal.
8. Michelson interferometer
9. Transition temperature in ferrites.
10. Determination of Zeeman splitting of mercury field.
11. Determination of Plank's constant
12. Study of electret.
13. NMR

STATISTICAL MECHANICS

Code PHM401 **Max. Marks 100**

UNIT 1 : Statistical basis of thermodynamics The macroscopic and the microscopic states, phase space, trajectories and density of states, Liouville's theorem, ensemble theory, the principle of maximum entropy, contact between statistical mechanics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox. (10 lectures)

UNIT 2 : Canonical and grand-canonical ensembles Classical canonical ensemble, partition function, calculation of statistical quantities, Energy fluctuations. The grand canonical ensemble, particle number fluctuation. Entropy in grand canonical ensemble, thermodynamic potentials. (12 lectures)

UNIT 3 : Quantum Statistical Mechanics Postulates of quantum statistical mechanics, density matrix, statistics of ensembles. Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation. (10 lectures)

UNIT 4 : Phase transitions Type of phase transitions, first and second order phase transitions. Ising model, mean-field theories of the Ising model in two and three dimensions, exact solution in one dimension. Connection of Ising model to lattice gas and binary alloy models. Landau theory of phase transition, Landau free energy for second and first order transitions, critical exponents and universality classes. (12 lectures)

REFERENCES

1. Statistical and Thermal Physics, by F. Reif
2. Statistical.Mechanics, by K. Huang
3. Statistical Mechanics, R K Pathria
4. Statistical Mechanics, R. Kubo
5. Statistical Physics, Landau and Lifshitz
6. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker
7. Statistical Physics by F. Mandl

GROWTH AND IMPERFECTIONS OF MATERIALS

Code PHM402M **Max. Marks 100**

UNIT 1 : Experimental Methods of Crystal Growth Crystal growth from solution, melt and vapour; Flux and Hydrothermal method, Bridgman-Stockbarger and Czochralski method, Float zone andZone refining techniques, purification of materials. (11 Lectures)

UNIT 2 : Kinetics of Crystal Growth Nucleation kinetics, Homogenous and heterogenous nucleation theories of crystal growth, Koesel's theory, The Diffusion theory, Bulk diffusion model, BCF bulk diffusion model, Growth mechanism, Screw dislocation mechanism of crystal growth and polytypism, Experimental verification. (11 lectures)

UNIT 3 : Atomic Packings in Crystals Close packing of spheres, Axial ratio and lattice constants, Voids in close-packing, Coordination of voids, Rules governing the packings of atoms, Effect of radius ratio, Application of Pauling rules to actual structures, Representation of closest packings polymorphic and polytypic structures, Polytypic notations, Stacking faults in fcc, hcp crystals. (11 lectures)

UNIT 4 : Atomic Imperfections in Crystals Point imperfection in ionic crystals, Line imperfection, Edge and Screw dislocation, Burgers vector and Burger's circuit, Dislocation motion, Energy of dislocation, Slip planes and slip directions, Perfect and imperfect dislocations, Dislocation reaction, Surface imperfections, Grain boundary, Tilt and Twist boundary. (12 lectures)

REFERENCES

1. R.A. Laudise: The Growth of Single Crystal.
2. J.J. Gilman: The Art & Science of growth crystals.
3. L.V. Azroff: Introduction to Solids.
4. A.J. Dekker: Solid State Physics.
5. A.R. Verma and P. Krishna: Polytypism and polytypism in crystals.
6. V. Raghavan: Material Science and Engineering
7. Ibach & Luth: Solid State Physics
8. Kittel: Introduction to Solid State Physics
9. M.A. Wahab: Solid State Physics (Structure and properties of Materials)
10. M.A. wahab: Essential of Crystallography

PHOTONICS

Code PHM402L **Max. Marks 100**

UNIT 1 : Review of Optics: Optical components, Planar and Spherical boundaries and Lenses, Graded index components. Matrix optics: matrices of simple optical components, Wave Optics: Complex representation of monochromatic wave and Helmholtz equation, Fresnel approximation of the spherical wave : Parabolodal wave, Transmission through optical components, Multiple beam Interference. Fabry-Perot Interferometer. Polychromatic light - Fourier decomposition. (12 Lectures)

UNIT 2 : Fourier Optics: Propagation of light in free space- transfer function of free space, Optical Fourier Transform, Diffraction Integral, Fourier transform using a lens, image formation and spatial frequency filtering. Holography: Fourier Transform Holography. (7 Lectures)

UNIT 3 : Polarization of Light, Optics of anisotropic media: The index ellipsoid, Birefringence, Optical activity and Faraday effect. Polarization devices: Wave retarders, rotators and optical isolators. Electro-optics: Pockels and Kerr Effect- Electro-optics of Anisotropic media, Phase and amplitude modulators, Photorefractive materials. Acousto-optics: Accousto-optics- Bragg diffraction and acousto-optic devices. (11 Lectures)

UNIT 4 : Non-linear Optics: Non-linear optical media, second order non-linear optics-SHG, Three wave mixing. Third order non-linear optics, THG and self phase modulation, Coupled wave theory of three-wave mixing. Four wave mixing and Optical Phase conjugation. Frequency conversion, Parametric Amplification and Oscillation. Self focusing of light. Optical Bistability: Bistable Systems, Principle of optical bistability, Bistable Optical devices. (15 Lectures)

REFERENCES

1. A. Ghatak and K. Thyagarajan : Optical Electronics (Cambridge University Press)
2. Fundamentals of Photonics: B.E.A. Saleh and M.C. Teich
3. A. Yariv : Quantum Electronics (Wiley, New York)
4. M. Young : Optics and Lasers (Springer Verlag)

GENERAL RELATIVITY

Code PHM402T **Max. Marks 100**

Unit 1 : Review and Introduction Gravitational and Inertial mass. Equivalence Principle. Special relativity. Minkowski space-time. Einstein's argument of 1907 on slowing down of clocks in gravitational fields. (5 lectures)

Unit 2 : Tensor Calculus Vector and tensor fields. Parallel transport. Connection coefficients. Metric tensor. Covariant derivative. Geodesic equation. Riemann curvature tensor. Symmetry properties of Riemann tensor. Bianchi identity. Ricci and Einstein tensor. Einstein equation. (10 lectures)

Unit 3 : Gravity in Simple Situations Motion along a geodesic. Newtonian approximation. Gravitational redshift. Einstein equation in vacuum. Schwarzschild solution. Planetary motion and precession of the perihelion. Bending of light by a gravitating body. (10 lectures)

Unit 4 : Weak Fields Stress-energy tensor for a perfect fluid. Solution of Einstein equation for weak fields. Energy psuedo-tensor for the gravitational field. Gravi-magnetic effects. Gravitational waves. (10 lectures)

Unit 5 : Special Topics Action principle for gravitational and matter fields. Schwarzschild solution extension in Kruskal-Szekeres coordinates. Kerr solution. Black holes. (10 lectures)

REFERENCES

1. J.B.Hartle : Gravity
2. S.Weinberg : Gravitation and Cosmology.
3. L.D.Landau and E.M.Lifshitz : The Classical Theory of Fields.
4. R.M.Wald : General Theory of Relativity
5. C.W.Misner, K.S.Thorne and J.A.Wheeler : Gravitation
6. Pankaj Sharan : Spacetime, Geometry and Gravitation

CHARACTERISATION OF MATERIALS

Code PHM403M **Max. Marks 100**

UNIT 1 : Optical methods of structure determination Optical microscopy, Raman spectroscopy, Photoluminescence, Scanning Electron Microscopy (10 Lectures).

UNIT 2 : Surface Scanning Techniques AFM, Electron Diffraction, TEM, STM, Low Energy Electron Diffraction, Reflection High Energy Electron Diffraction (10 Lectures).

UNIT 3 : Surface analytical techniques Auger electron spectroscopy, X-Ray photoelectron spectroscopy, SIMS, Rutherford backscattering (10 Lectures).

UNIT 4 : X-Ray Diffraction Studies Diffraction phenomena as applied to Solid State problems, scattering and absorption of X-rays, neutrons and electrons. X-ray method for orienting crystals. Applications of XRD. Diffraction from regular and faulted closed packed structures. Broadening of diffraction spots due to defects. Line prifile analysis, crystal structure analysis, measurement of intensities of X-ray reflection (15 Lectures).

REFERENCES

1. Woodruff and Delchar : Experimental techniques of surface science
2. Ashcroft and mermin : Solid State Physics
3. S.R.Elliot : Amorphous Materials
4. L.C.Feldman and J.W.Mayer : Fundamentals of surfaces and thin film analysis
5. M.M.Wofson : An introduction of X-ray crystallography
6. J.C.Anderson : Use of films in Physical investigations
7. W.K.Chu : Rutherford backscattering Spectroscopy

QUANTUM OPTICS

Code PHM403L **Max. Marks 100**

UNIT 1 : Quantum theory of radiation : Quantization of free em fields, fockstates, lambshift, quantum beats, concept of photons, coherent and squeezed states of lights, quantum distribution theory and partially coherent radiation. (16 Lectures)

UNIT 2 : First and second-order coherence, HBT effect, photon bunching and anti bunching, Poissonian and sub-poissonian light, photon counting and photon statistics, Atom-field interaction : semi classical theory and quantum theory, coherent trapping, electromagnetically induced transparency and lasing without inversion. (16 Lectures)

UNIT 3 : Quantum theory of damping : density operator method and langevin approach, quantum theory of laser, squeezing of light in nonlinear optical process, Atom optics : mechanical effects of light, atomic interferometry, quantum noise in an atomic interoferometer, limits to laser cooling. (6 Lectures)

UNIT 4 : Introductory ideas on EPR paradox, Bells inequality, QND measurements and two photon interferometry. (7 Lectures)

REFERENCES

1. Elements of quantum optics : Meytre-Sergent
2. Quantum optics : M.O.Scully and M.S. Zubairy
3. Optical coherence and quantum optics : Mandel and Wolf
4. Laser physics : Sargent,Scully and Lambs

PARTICLE PHYSICS

<u>**Code PHM403T**</u> <u>**Max. Marks 100**</u>

UNIT 1 : Invariance Principles and Symmetries Charge conjugation, time reversal and partity , CPT theorem, Quark model and color and flavour quantum numbers, Weak isospin and hypercharge. (10 lectures)

UNIT 2 : Introduction to Gauge Theories Abelian and non-abelian gauge theories, Spontaneous symmetry breaking, Goldstone theorem, Higgs phenomenon. (10 lectures)

UNIT 3 : Standard Model Historical introduction to Fermi theory and current algebra, Weinberg-Salam model, Basic Lagrangian, neutral current, GIM mechanism, KM matrix and CP violation. (10 lectures)

UNIT 4 : Strong Interactions Basic Lagrangian of QCD and its symmetries, Asymptotic freedom, Deep inelastic scattering. (10 lectures)

UNIT 5 : Some Special topics Anamolies, supersymmetry, string theory. (5 lectures)

<u>**REFERENCES**</u>

1. Perkins: Introduction to High Energy Physics (Addison-Wesley 3rd Edition)
2. Greiner & Muller: Gauge Theory of Weak Interactions (Springer)
3. Cheng Lee: Gauge Theory and Particle Physics (Cambridge)

MATERIALS LAB

Code PHM404M **Max. Marks 100**

1. To study the strength, hardness and conductivity of the materials.
2. To grow single crystal of NaCI from solution and take its Laue photograph. Index this photograph using Gonomonic projection.
3. To take Debye Scherrer pattern of a given polycrystalline material and determination of their "d" values from the powder lines.
4. Setting of single crystal using Goniometer and detennination of the identity period of a given crystal using Rotation method.
5. To find the wave length of K-absorption edge of Zr using Mo target and Bent crystal spectrograph.
6. Study of superconductivity
7. Study of the Molumine scene of F-centres in alkali halide crystals.

LASER LAB

Code PHM404L **Max. Marks 100**

1. Absorption spectrum of benzene.
2. Fluoroscence spectrum of a dye.
3. To study the Raman effect and to find the values of Raman frequencies for a substance.
4. Determination of power distribution in a laser beam spot size and the divergence of the beam.
5. Holography.
6. Electrooptic modulation.
7. Optical fibre.
8. Acousto-optic modulation.
9. Fabry-Perrot interferometer
10. Mach-Zehnder interferometer
11. Diffraction of light.
12. Polarization of light.

QUANTUM FIELD THEORY

Code PHM404T **Max. Marks 100**

UNIT 1 : Canonical Quantization Canonical quantization of neutral scalar, Charged scalar, spin 1/2 and massive spin-1 fields, Fock space and observables. Field commutation, anti-commutation relations. (12 lectures)

UNIT 2 : Interacting Fields Interaction picture. Normal product. Wick's theorem. Feynman propagator. S-matrix. Feynman rules and diagrams. (9 lectures)

UNIT 3 : Quantum Electrodynamics Quantization of electromagnetic field. Gupta-Bleuler condition. Indefinite metric. Feynman diagrams of QED. (8 lectures)

UNIT 4 : Scattering (tree level) in QED Tree level calculations of Moller, Bhabha, Compton and Scattering in external field. (8 lectures)

UNIT 5 : Special topics 1-loop corrections and renormalization. RG equations. (8 lectures)

REFERENCES

1. S.S. Schwebber : Introduction to Relative Quantum Field Theory (Inter science 1961)
2. Bogolinbov & Shirkov : Introduction to Quantized Field Theory
3. Bjorken & Drell : Relativistic Quantum Mechanics
4. Bjorken & Drell : Quantum Field Theory
5. Itzyksen & Zuber : Quantum Field Theory (Mc Graw Hill)

PROJECT

<u>**Code PHM405**</u> <u>**Max. Marks 100**</u>

Guidelines for Project in M.Sc. Course:

1. Projects would be allotted to III Sem students which have to be carried out and completed in Sem IV.

2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest.

3. The project will comprise of the following:

a. Study of background material

b. Collection of data, procurement and fabrication of experimental set up and writing of computer programs if needed.

c. Giving a preliminary seminar in the III sem for the purpose of internal assessment whose weightage would be 50 marks (2 credits).

d. Writing a dissertation or project report. This will be submitted by the students at the end of IV semester.

4. The Final evaluation of the project work completed will be done by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report. The weightage of the final evaluation would be 80 percent.

M.Sc.

Sl. No.	Name of the Paper	Paper Type	Paper Code	Credits	Periods/week
	Semester I				
1	Quantum Mechanics I	Core	PHM11C	4	4
2	Mathematical Physics I	Core	PHM-12C	4	4
3	Classical Mechanics	Core	PHM-13C	4	4
4	Electronics	CBE	PHM-11E	4	4
5	Lab I	Lab	PHM-11L	6	12
	Semester II				
1	Condensed Matter Physics I	Core	PHM-21C	4	4
2	Quantum Mechanics II	Core	PHM-22C	4	4
3	Electrodynamics	Core	PHM-23C	4	4
4	Mathematical Physics II	CBE	PHM-21E	4	4
5	Experimental Techniques	SEC	PHM-21A	4	4
6	Lab II	Lab	PHM-21L	6	12
	Semester III				
	Material Science Specialization				
1	Atomic & Molecular Physics	Core	PHM-31C	3	3
2	Nuclear & Particle Physics	Core	PHM-32C	3	3
3	Advanced Topics in Material Science	Core	PHM-33CM	4	4
4	Lab III	Lab	PHM-31L	6	12
5	Numerical Analysis & Programming	AEC	PHM-31A	4	4
	Laser &Spectroscopy Specialization				
1	Atomic & Molecular Physics	Core	PHM-31C	3	3
2	Nuclear & Particle Physics	Core	PHM-32C	3	3
3	Laser Physics	Core	PHM-33CL	4	4
4	Lab III	Lab	PHM-31L	6	12
5	Numerical Analysis & Programming	AEC	PHM-31A	4	4
	Theory Specialization				
1	Atomic & Molecular Physics	Core	PHM-31C	3	3

2	Nuclear & Particle Physics	Core	PHM-32C	3	3
3	Classical Field Theory	Core	PHM-33CT	4	4
4	Lab III	Lab	PHM-31L	6	12
5	Numerical Analysis & Programming	AEC	PHM-31A	4	4
Electives					
6	Characterization of Materials	CBE	PHM-31E	4	4
7	Photonics	CBE	PHM-32E	4	4
8	General Relativity	CBE	PHM-33E	4	4
Semester IV					
Material Science Specialization					
1	Statistical Mechanics	Core	PHM-41C	4	4
2	Condensed Matter Physics II	Core	PHM-42C	4	4
3	Phys &Tech of Semiconductor Devices	Core	PHM-43CM	4	4
4	Project	Project	PHM-44	4	
Laser &Spectroscopy Specialization					
1	Statistical Mechanics	Core	PHM-41C	4	4
2	Condensed Matter Physics II	Core	PHM-42C	4	4
3	Quantum Optics	Core	PHM-43CL	4	4
4	Project	Project	PHM-44C	4	
Theory Specialization					
1	Statistical Mechanics	Core	PHM-41C	4	4
2	Condensed Matter Physics II	Core	PHM-42C	4	4
3	Particle Physics	Core	PHM-43CT	4	4
4	Project	Project	PHM-44C	4	
Electives					
5	Physics of Novel Materials	CBE	PHM-41E	4	4
6	Laser Spectroscopy	CBE	PHM-42E	4	4
7	Quantum Field Theory	CBE	PHM-43E	4	4

Semester I

Core Course **Quantum Mechanics I** **PHM-11C**

Unit I: Mathematical Tools

Brief introduction to origins of quantum Physics. Wave packets. Dirac notation. Operators, their eigenvalues and eigenfunctions, orthonormality, completeness and closure. Generalized uncertainty principle. Unitary transformations, change of basis. Matrix Representation of operators. Continuous basis, position and momentum representation and their connection.Parity operator.

Unit II: Fundamental Concepts of Quantum Mechanics

Basic postulates of quantum mechanics. Measurement. Time evolution of system's state. Schr¨odinger, Heisenberg and interaction pictures. Density operator. Pure state and mixed state density operators. Discrete and continuous spectra in 1-D. Solution of 1-D harmonic oscillator using algebraic method.

Unit III: Angular Momentum

Orbital, Spin and total angular momentum operators. Pauli spin matrices, their Commutation relations. Eigenvalues and eigenfunctions of L 2 and L z . Angular momentum as generator of rotation. Addition of angular momenta. Clebsch-Gordon coeficients. L-S coupling.

Unit IV: Identical Particles

Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The Puli exclusion principle. Introduction to second quantization. Creation and annihilation operators for Fermions and Bosons. Fock states.

Reference Books:

1. Quantum Mechanics : N. Zettili
2. Quantum Mechanics : Franz Schwabl
3. Modern Quantum Mechanics : J.J.Sakurai
4. Priciples of Quantum Mechanics : P. A. M. Dirac
5. Quantum Mechanics : Bohm

Semester I

Core Course **Mathematical Physics I** **PHM-12C**

Unit I: Complex Analysis

Advanced complex analysis : Brief description of functions of complex variables with examples, mappings, limits, continuity, differentiation, analytic functions, branch cut, branch point, line integral, simply and multiply connected domains, Taylor and Laurent series : convergence, residues and poles, contour integrals, 2-dimensional Laplace equation

Unit II: Partial Differential Equations

Partial differential equations : 1-dimensional - vibrating string, heat flow, 2-dimensional - vibrating membrane, 3-dimensional – Wave equation, Laplace equation : potential theory, diffusion equation

Unit III: Green's Function

Green's function : Method for boundary value problems, GF in one dimension, eigenfunction expansion of Green's function, multidimensional GF's, examples : elliptic, parabolic and hyperbolic equations

Unit IV: Integral equations

Integral equations : Classification, Fredholm and Volterra integral equations, Transformation of a differential equation into integral eq., Hermitian Kernel, degenerate kernels, Fredholm alternative, integral transforms, successive approximations, successive substitution, resolvent kernel, Hilbert-Schmitt theory

Unit V: Tensor Analysis

Contravariant vectors, Covariant vectors, Coordinate transformation from one coordinate system to another, Various coordinate systems (Cartesian, Cylindrical, Spherical Polar, Oblique axes etc.), Addition and subtraction of tensors, symmetric/anti-symmetric tensor, outer multiplication, contraction, inner multiplication, quotient theorem. Inertia tensor, definition, derivation of expression, calculation of it's components, stress, strain and elastic constant tensors, Chistoffel symbols, Riemann curvature tensor

Reference Books:

1. Complex variables and applications by Churchill & Brown, IV Ed, MGH
2. Mathematical Physics, Sadri Hassani, II Ed., Springer
3. Mathematical methods for physicists, 6th Ed., Arfken& Weber, Elsevier
4. Tensors by De, Sheikh and Sengupta, Narosa.

Semester I

Core Course **Classical Mechanics** **PHM-13C**

Unit I: Lagrangian Formalism

Newtonian mechanics and its limitations. Constrained motion. Constraints and their classification. Principle of virtual work. D' Alembert's principle. Generalised coordinates. Deduction of Lagrange's equations from D' Alembert's Principle. Generalised momenta and energy. Cyclic or ignorable coordinates. Rayleigh' s dissipation function. Integrals of motion. Symmetries of space and time with conservation laws.

Unit II: Hamiltonian formalism

Principle of least action. Hamilton's principle. The calculus of variations. Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle. Hamilton's principle and characteristic functions.

Unit III: Canonical Transformation

Canonical Transformations. Generating functions. Poisson bracket. Poisson's Theorem. Invariance of PB under canonical transformations. Angular momentum PBs. Hamilton-Jacobi equation. Connection with canonical transformation. Problems.

Unit IV: Rigid Body Dynamics

Rotational motion, moments of inertia, torque. Euler's theorem, Euler angles. Symmetric top. Gyroscopes and their applications.

Unit V: Small Oscillations and Nonlinear Dynamics

Small Oscillations. Normal modes and coordinates. Applications. Perturbations and KAM theorem, Attractors, Chaotic trajectories and Liapunov exponents, Poincare maps, bifuractions, Logistic equation, Fractals and dimensionality

Reference Books:

1. Classical Mechanics: H. Goldstein.
2. Mechanics: L. D. Landau and E. M. Lifshitz
3. Classical Mechanics: N.C.Rana and P.S.Joag.
4. Theoretical Mechanics: Murray Spiegel.
5. Classical Mechanics Systems of Particles and Hamiltonian Dynamics:Walter Greiner

Semester I

Choice Based Elective **Electronics** **PHM-11E**

Unit I: Semiconductor Devices I

Semiconducting Materials, conduction in semiconductors, Charge densities in a semiconductors, PN junction, space charge and electric field distribution at junctions, forward and reverse biased conditions, Space charge capacitance, varactor diode, Zener and avalanche breakdowns, zener diode, tunnel diode, photodiode, LED, p-n-p-n devices and their characteristics, SCR.

Unit II: Semiconductor Devices II

Transistors: Bipolar junction Transistor (BJT), Ebers Moll Model, Analysis of CE amplifier using h-parameters, The T-network equivalent circuit, constants of CB and CE amplifier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field-Effect Transistors (FET) and MOSFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions.

Unit III: Feedback Principle

Negative feedback, effect of negative feedback on input/output resistances and voltage gain, gain stabilization, effect of negative feedback on band width, voltage series feedback, voltage shunt feedback applied to BJT, current series feedback, current shunt feedback applied to BJT

Unit IV: Microwave Electronics

Microwaves, Principle of velocity modulation and bunching of electrons, Basic principles of two cavity klystrons and Reflex Klystrons, operation of magnetrons, characteristics of microwave diode.

Reference Books:

1. Electronic Fundamentals and Applications : John D. Ryder
2. Electronic Devices and Circuits : Millman and Halkins
3. Solid State Electronic Devices : Ben G. Streetman
4. Electronics : Ramabhadran S.
5. Electronics Devices and Circuit theory : Boylested and Nashelsky
6. Pulse, Digital and Switching Waveforms : Millman and Taub
7. Fundamental of Transistor : S.W. Amos
8. Microwave Principle : W.J. Reich
9. Microwaves : K.L. Gupta
10. Introduction to Microwave : G.J.Wheeler;
11. Semiconductor Devices- Physics and Tecnology : S.M. Sze.

Semester I

Physics Practical **Lab I** **PHM-11L**

List of Experiments :

1. PN Junction : To find the band gap of the semiconductor
2. CE Amplifier (Bread Board) : To find bandwidth of capacitive coupled common emitter amplifier
3. Transistor Biasing : To study various biasing techniques, viz i) self bias ii) fixed bias, iii) voltage divider biasing, and to find the best biasing by observing the temperature effect on output waveform
4. FET : To find input and transfer characteristics of Field Effect Transistor
5. MOSFET : To find input and transfer characteristics of MOSFET
6. Op-Amp : To make inverting/non-inverting amplifiers, buffer, integrator and differentiator circuits using operational amplifier
7. To study Feedback in Transistors : a) series-series b) series-shunt c) shunt-series iv) shunt-shunt feedbacks
8. IC555 (BB) : To make astable and monostable vibrator using IC555
9. Phase Shift Oscillator (BB) : To make RC phase shift oscillator using 3 and 4 RC networks and compare experimental and theoretical frequencies
10. To study Amplitude Modulation & Demodulation and to calculate modulation index
11. To make Astable multivibrator using bipolar transistor
12. Optoelectronic kit : to study characteristics of i) Light Emitting Diode, ii) Temperature Dependent Resistance, iii) light dependent transistor
13. To study Analog to Digital conversion
14. To study Digital to Analog conversion
15. To study Frequency Modulation & Demodulation and to calculate modulation index
16. To study PAM (Pulse Amplitude Modulation) circuit
17. To study PCM (Pulse Code Modulation) circuit
18. To study PWM (Pulse Width Modulation) and PPM (Pulse Position Modulation) circuits

Semester II

Core Course **Condensed Matter Physics I** **PHM-21C**

Unit I: Bonding in crystals

Covalent, ionic, metallic, hydrogen bond, van der Waal's bond and the Madelung constant. Crystalline solids, unit cell, primitive cell, Bravais lattices, Miller indices, closed packed structures. Atomic radius, lattice constant and density. Connection between orbital symmetry and crystal structure. Scattering from periodic structures, reciprocal lattice, Brillouin Zones.

Unit II: Phonons - Lattice Dynamics and Thermal Properties.

Lattice dynamics of atoms in crystals, vibrations of monoatomic and diatomic linear chains, acoustic and optical phonon modes, density of states, thermal properties of crystal lattices, thermal energy of the harmonic oscillator, specific heat capacity of the lattice, Debye theory of specific heats.

Unit III: Free Electron Theory

Free electrons in solids, density of states, Fermi surface, Fermi gas at T=0 K, Fermi statistics, specific heat capacity of electrons in metals, thermionic emission of electrons from metals.

Unit IV: Electronic Band Structure

Electronic band structure in solids, Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model : density of states, examples of band structures. Fermi surfaces of metals and semiconductors.

Unit V: Transport properties

Motion of electrons in bands and the effective mass, currents in bands and holes, scattering of electrons in bands, Boltzmann equation and relaxation time, electrical conductivity of metals, thermoelectric effects, the Wiedemann-Franz Law.

Reference Books:

1. Solid State Physics : Hook and Hall : Hook and Hall
2. Introduction to Solid State Physics : Kittel
3. Solid State Physics : Ibach and Luth
4. Introduction to the Theory of Solids : H. M. Rosenberg
5. Solid State Physics : Blakemore
6. Solid State Physics : Ashcroft and Mermin

Semester II

Core Course | **Quantum Mechanics II** | **PHM-22C**

Unit I: Approximation methods for stationary systems

Time independent perturbation theory. Perturbation of non-degenerate states: first and second order perturbation. Perturbation of a harmonic oscillator. Perturbation of degenerate states, removal of degeneracy. Zeeman and Stark effects. Variational and WKB methods.

Unit II: Approximation methods for non-stationary systems

Schroedinger, Heisenberg and interaction pictures, Equations of Motion. Constant and harmonic perturbation. Discrete and continuous case, transition probability. Fermi golden rule. Adiabatic and sudden approximations.

Unit III: Scattering Theory

Scattering of a wave packet. The differential and total Cross section. The Born approximation. Partial waves and phase shifts. The Lippmann Schwinger equation. Definition and properties of S-matrix, T matrix. Optical theorem

Unit IV: Relativistic Quantum Mechanics

Klein-Gordon and Dirac equations, properties of Dirac matrices. Lorentz and CPT invariance of Dirac equation. Non-relativistic reduction of the Dirac equation. Central forces and the hydrogen atom.

Unit V: Solution to Dirac Equation

Free particle solution, hydrogen atom in dirac's theory, Dirac electron in constant magnetic field, Foldy-Wouthuysen transformation, Hole theory.

Reference Books :

1. Quantum Mechanics : Franz Schwabl
2. Quantum Mechanics : Eugen Merzbacher
3. Quantum Mechanics : N. Zettili
4. Quantum Mechanics : P. M. Mathews and K. Venkatesan
5. Principles of Quantum Mechanics : P. A. M. Dirac

Semester II

Core Course **Electrodynamics** **PHM-23C**

Unit I: Electrodynamics : Potential formulation and Conservations laws

Review of Maxwell's equations. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz Gauge, Conservation of energy and momentum, Poynting's theorem, Maxwell's Stress tensor.

Unit II: Wave equation: retarded solutions

Inhomogeneous wave equations, Green's functions for Poisson, Helmholtz and Wave equations. Retarded and Advanced solutions for Maxwell's equations. Jefimenko formulas for fields for charge and current distributions.

Unit III: Radiation by moving charge

Lienard-Wiechert Potentials. Electromagnetic field of a moving point charge. Radiation from an accelerated charge, Larmor's formula and Lienard's generalization (relativistic); Angular distribution of radiated power for linearly and circularly accelerated charges, Bremsstrahlung, Synchrotron, Cherenkov radiation (qualitative treatment only).

Unit IV: Radiation damping

Radiation reaction from energy conservation, Abraham-Lorentz formula, Self force.

Unit V: Relativistic Electrodynamics

Review of STR. Lorentz transformations. Electromagnetic field tensor, Transformation of electromagnetic fields, Covariant formulation of electrodynamics. Field due to a point charge in uniform motion, Energy-momentum tensor and the conservation laws for the electromagnetic field; the equation of motion of a charged particle in an electromagnetic field; Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

Reference Books:

1. Classical Electrodynamics : J.D. Jackson,
2. Classical Theory of Fields : Landau & Lifshitz
3. Introduction to Electrodynamics: D. J. Griffiths
4. Foundations of Electromagnetic Theory : Reitz, Milford and Christy
5. Classical Charged Particle : Rohrlich

Semester II

Choice Based Elective **Mathematical Physics II** **PHM-21E**

Unit I: Vector spaces

Linear vector spaces : Vector spaces, inner product spaces, Cauchy sequence: eigenvalues, diagonalization and spectral theory , direct sum and product of matrices, Hilbert space : properties, function spaces, dual space, direct sum of function spaces, operators.

Unit II: Discrete groups

Discrete Groups : examples, multiplication table, conjugate elements and classes, subgroups, normal subgroups, factor groups, direct product of groups, isomorphism & homomorphism, group of symmetries of regular polygon, permutation groups,

Unit III: Representation of groups

Invariant subspaces and reducible representations, Schur's lemmas and the orthogonality theorem, characters of a representation, regular representation, symmetrized basis functions for irreducible representation, transfer and projection operators, direct product of representations, representations of a direct product group, examples

Unit IV: Continuous groups

Continuous groups : Topological groups and Lie groups, axial rotation group SO(2), 3-D rotation group SO(3), Lorentz group, Special Unitary group SU(2), generators of U(n) and SU(n), Lie algebra and representations of Lie group, Special Unitary group SU(3), examples

Unit V: Permutation groups

Permutation group, disjoint and non-disjoint cycles, transpositions, parity, generators, classes, character table, representations, partitioning of n, Young diagrams, Young tableau

Reference Books:

1. Elements of group theory for physicists, 4th Ed., A W Joshi, New Age Int.
2. Group Theory by Abbas, Taylor & Francis
3. Mathematical methods for physicists, 6th Ed., Arfken & Weber, Elsevier
4. Group Theory by Hamermesh
5. Mathematical Physics, by Sadri Hassani, II Ed., Springer

Semester II

Ability Enhancement course **Experimental Techniques** **PHM-21A**

Unit I: Basic Data processing

Recording and analysis of data, data uncertainty, Error: - accuracy and precision, computer-aided data acquisition

Unit II: Introduction to Vacuum

Fundamentals of Vacuum, Gas Flow Mechanism, Concept of Throughput and Pumping Speed, Various types of Pumps - Pressure Measurements gauges, valves, seals - Leak Detection techniques

Unit III: Thin Film deposition

Physical vapour deposition, thermal evaporation, e-beam evaporation, sputtering, pulsed laser deposition, molecular beam epitaxy, MOCVD.

Unit IV: Single Crystal growth

Bridgman-Stockbarger and Czochralski method, flux and hydrothermal method, purification of materials, zone refining.

Reference Books:

1. Vacuum Technology: Alexander Roth
2. The Growth of Single Crystals : R.A. Laudise
3. The Art & Science of Crystal Growth : J.J. Gilman.
4. Material Science and Engineering : V. Raghavan
5. Essentials of Crystallography : M.A. Wahab
6. Crystal growth for beginners : Ivan Markov
7. Physics of Crystal Growth: Alberto Pimpinelli and Jacques Villain

Semester II

Physics Practical **Lab II** **PHM-21L**

List of Experiments :

1. Study of radioactivity by using a G.M. tube to (i) Determine background radiation and (ii) Study absorption in air of β and γ radiation from ^{137}Cs and ^{60}Co sources.

2. Hall effect : Study of the dependence of Hall coefficient on temperature.

3. Determination of the magnetic susceptibility of $Mncl_2$ by Quincke's tube method.

4. Study of magnetoresistance of doped semiconductors.

5. Study of magnetic hysteresis in various ferromagnetic materials using a Hysterisis loop tracer .

6. Frank- Hertz experiment.

7. Determination of the dissociation energy of Iodine molecule.

8. Fourier analysis of sinusoidal, triangular and square waveforms.

9. Determination of the Curie temperature of ferroelectric materials.

10. Determination of the forbidden energy gap of semiconductors.

11. Determination of the e/m ratio of electrons by Thomson's method using a fine beam electron tube and Helmholtz coils.

12. Determination of the dielectric constants of amorphous and crystalline solids.

13. Determination of the Landé g factor of electrons using ESR.

14. Determination of ultrasonic velocity in liquids.

15. Study of the temperature dependence of resistivity of semiconductors by the 4-probe method.

16. Study of I-V characteristics, and determination of the fill-factor and efficiency of a solar photovoltaic cell.

17. Study of Zener and avalanche breakdown in P-N junction diodes as a function of Temperature.

Semester III

Core Course **Atomic & Molecular Physics** **PHM-31C**

Unit I: Basic Concepts

Review of Solution of Schroedinger's equation for Coulomb field and Hydrogen atom, dipole approximation, spectroscopic terms and selection rules, intensities of spectral lines.

Unit II: Interaction with Electromagnetic Field

Fine structure of Hydrogen like atoms: spin-orbit interaction, relativistic correction, Lamb shift. Interaction with external fields: Zeeman, Paschen-Back and Stark effects.

Unit III : Atomic Spectra

The LS-coupling approximation, J-J coupling, hyperfine structures. The central field approximation, Thomas Fermi-potential, alkali atom spectra, Na doublet.

Unit IV: Molecular Spectra

Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational-Vibrational and Electronic spectra of Di-atomic molecules, Selection rules, Frank-Condon principle, Raman spectra, NMR, ESR.

Reference Books:

1. Physics of Atoms and Molecules : B.H. Bransden & C.J. Joachain
2. Elementary Atomic Structure : G.K. Woodgate
3. Introduction to Modem Physics : H.S. Mani & G.K. Mehta
4. Molecular Spectra : G. Herzberg
5. Fundamentals of Molecular Spectroscopy : C.N. Banwell

Semester III

Core Course | **Nuclear & Particle Physics** | **PHM-32C**

Unit I: Basic Nuclear Concepts

Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei.

Unit II: Nuclear Forces

Characteristics of nuclear forces -Range and strength, Simple theory of two nucleon system - deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces.

Unit III : Energy deposition and Particle detection

Interaction of charged particles with matter. Stopping power and range. Detectors for energetic charged particles; Solid State or Semiconductor detector.

Unit IV: Particle Accelerators

Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; Alternating gradient accelerator, Colliding beam accelerator.

Unit V: Elementary particles

Classification and properties of elementary particles; Resonances ; Interactions and their mediating quanta, Conservation rules in fundamental interactions; Strangness and associated production, Isospin and its conservation. Parity and charge conjugation, Conservation of parity and its violation Idea of eight fold way and quarks.

Reference Books:

1. Nuclei and Particles : Segre
2. Nuclear Physics : Cohen
3. Nuclear Physics : Enge
4. Physics of Nuclei and Particles : Marmur and Sheldon
5. Introduction to Nuclear and Particle Physics : Das and Ferbel

<u>**Semester III**</u>

Core Course | **Advanced Topics in Material Science** | **PHM-33CM**

Unit I: Crystal structure, symmetry and electronic energy levels

Review of bonding in solids and electronic structure, link between valence electronic states and crystal symmetries, density of states for metals, semiconductors and insulators, dispersion of electron energy levels, van Hove singularities, energy bands, Fermi surfaces, De Haas - van Alphen effect.

Unit II: Experimental determination of electronic structure

X-ray and ultraviolet photoelectron spectroscopies and Auger electron spectroscopy. Chemical shift determination. Calculation of electronic energy levels and their dispersion, using angle-resolved photoemission spectra.

Unit III: Density Functional Theory

Extension of Central Field Approximation, Hohenberg-Kohn Theorems, statement and proof. Kohn Sham orbitals, pseudo potentials, the self-consistent field method for the calculation of ground state energies in DFT.

Unit IV: Crystal growth and defects

Kinetics of Crystal Growth: homogenous and heterogenous nucleation, diffusion and screw dislocation mechanism of crystal growth. Atomic imperfections in crystals- one, two and three dimensional imperfections, Schottky and Frenkel defects, Burger's vector and Burger's circuit, energy of dislocations, grain boundaries and surface reconstructions.

Reference Books:

1. Intro. To Solid State Physics: Chales Kittel
2. Solid State Physics : Ibach & Luth
3. Quantum Theory of Solids : Charles Kittel
4. Solid State Physics: Ashcroft and Mermin
5. Experimental Techniques of Surface Science : Woodruff and Delchar
6. Density Functional Theory: Kieron Burke.
7. Electronic Structure: Richard M. Martin
8. Crystal growth for beginners : Ivan Markov
9. Physics of Crystal Growth: Alberto Pimpinelli and Jacques Villain
10. Material Science and Engineering : V. Raghavan

Semester III

Core Course **Laser Physics** **PHM-33CL**

Unit I: Optical Resonators and Gaussian Beam

Brief review of matrix optics, Planar Mirror Resonators, Resonator Modes, Two- and Three-Dimensional Resonators, Spherical-Mirror Resonators, Ray confinement, Gaussian waves and its characteristics: The Gaussian beam, Transmission through optical component, Gaussian Modes, Resonance Frequencies, Hermite-Gaussian Modes, Finite Apertures and Diffraction Loss.

Unit II: Photons and Atoms

The Photon Optics theory of light in a resonator, Photon Polarization, Transmission and interference of photon, Photon time, Photon streams. Energy levels and Occupation of energy levels in thermal equilibrium, Interaction of single mode light with an atom, Spontaneous Emission, Transition Probabilities, Stimulated Emission and absorption, line shape function, Transition in presence of broadband light, Lineshape broadening: Homogeneous and Inhomogeneous Broadening. Lifetime broadening, Collision Broadening, Doppler Broadening.

Unit III : LASER Amplifiers

Theory of laser amplifiers, Gain and band width, Phase shift, Rate equations, pumping schemes, Common Laser amplifiers, Doped glass amplifiers, Amplifier Nonlinearity and stability saturation-saturated gain in homogeneously and inhomogeneously broadened media. Amplifier noise.

Unit IV: Lasers

Theory of laser oscillation, Optical amplification and feedback, Condition for laser oscillation, Characteristics of laser output, Mode selection, Common lasers; Selected characterises of common lasers, Pulsed lasers: Methods of pulsing lasers, Q-switching, Mode locking.

Reference Books:

1. Introduction to Laser Physics : K.Shimoda
2. Principles of Lasers : O. Svelto
3. Lasers- Theory and Applications : Thyagarajan and Ghatak
4. Fundamentals of Photonics: B.E.A. Saleh and M.C. Teich

Semester III

Core Course **Classical Field Theory** **PHM-33CT**

Unit I: Review of Classical Physics

Hamiltonians and Lagrangians. Legendre transforms and their properties. Euler-Lagrange equations. Principle of least action. (Functional calculus.) What is classical field theory? Group theory from invariances of classical equations. Newton's equations and the Galilean group. Maxwell's equations. Special Relativity and the Lorentz group. Vectors and tensors of the rotation and Lorentz groups.

Unit II: Basics of CFT

Systems with infinite degrees of freedom. Locality in space and time. Lagrangian densities for real and complex scalar fields. Euler-Lagrange (EL) equations. Functional calculus revisited. Hamiltonian density. The energy-momentum tensor. Finite-energy time-independent solutions -- classical vacua. Kinks in the Sine-Gordon and φ^4 theories. Green functions as singular solutions. Boundary conditions.

Unit III: Symmetries : Secret Symmetry and Local Symmetries

Discrete and continuous symmetries. Noether's theorem: the energy momentum tensor, the generalized angular momentum and the electromagnetic current. (Lie groups and Lie algebras. Representations of groups.) Global symmetries. Spontaneous breakdown of symmetry. Goldstone's theorem. (Coset spaces in group theory.) Abelian gauge fields. Covariant derivatives and minimal coupling. The abelian Higgs model. Vortex solutions (in type II superconductors). Topological conservation laws. The abelian Higgs mechanism.

Unit IV: The massless vector field

The Lagrangian density. Gauge invariance and the electromagnetic field strength. Maxwell's equations. Lorentz invariants of the field strength. The symmetrized energy-momentum tensor. The generalized angular momentum and the spin of the photon.

Unit V: Solitons and Instantons

Solitons as finite-energy solutions. Derrick's theorem. Getting around Derrick's theorem. Local symmetries and gauge fields. Abelian vortices. The Dirac monopole as a singular solution of Maxwell's equations. Dirac quantization. Instantons as finite action solutions to the EL equations.The 't Hooft solution. Nahm and Bogomolnyi equations from dimensional reduction.

Reference Books:

1. The Classical Theory of Fields : L. D. Landau and E. M. Lifshitz.
2. Classical Fields : M. Carmeli,
3. Electrodynamics and Classical Theory of Fields : A. O. Barut,
4. Aspects of Symmetry : S. Coleman,
5. Solitons and Instantons: R. Rajaraman

<u>Semester III</u>

Choice Based Elective | **Characterization of Materials** | **PHM-31E**

Unit I: Optical methods of structure determination

Optical microscopy, Raman spectroscopy, UV-Vis absorption spectroscopy, FTIR spectroscopy, Photoluminescence

Unit II: Determination of Surface Structure

Microscopy techniques: SEM, AFM, TEM, STM. Electron Diffraction techniques : Low Energy Electron Diffraction, Reflection High Energy Electron Diffraction.

Unit III: Surface analytical techniques for electronic structure

Auger electron spectroscopy, X-Ray photoelectron spectroscopy, SIMS, Rutherford backscattering

Unit IV: X-Ray Diffraction Studies

Diffraction phenomena as applied to Solid State problems, scattering and absorption of X-rays, neutrons and electrons. X-ray method for orienting crystals. Applications of XRD. Diffraction from regular and faulted closed packed structures. Broadening of diffraction spots due to defects. Line prifile analysis, crystal structure analysis, measurement of intensities of X-ray reflection.

Reference Books:

1. Experimental techniques of surface science : Woodruff and Delchar
2. Solid State Physics : Ashcroft and Mermin
3. Amorphous Materials : S.R.Elliot
4. Fundamentals of surfaces and thin film analysis : L.C.Feldman and J.W.Mayer
5. An introduction of X-ray crystallography : M.M.Wofson
6. Use of films in Physical investigations : J. C. Anderson
7. Rutherford backscattering Spectroscopy : W. K. Chu

Semester III

Choice Based Elective | **Photonics** | **PHM-32E**

Unit I: Polarization Optics

Polarization of Light, Optics of anisotropic media: The index ellipsoid, Birefringence, Polarization devices: Wave retarders, rotators and optical isolators. Magneto-Optic effect: Optical activity and Faraday effect

Unit II: Electro-optics and Acousto-optics

Pockels and Kerr Effect- Electro-optics of Anisotropic media, Phase and amplitude modulators, Beam Deflection and scanning devices, Photorefractive materials. Acousto-optics, Bragg diffraction and acousto-optic devices and their applications.

Unit III: Non-linear Optics and Optical Bistability

Non-linear optical media, second order non-linear optics- SHG, Three wave mixing. Third order non-linear optics, THG and self phase modulation. Four wave mixing and Optical Phase conjugation. Frequency conversion, Parametric Amplification and Oscillation. Self focusing of light. Bistable Systems, Principle of optical bistability, Bistable Optical devices, Optical logic and switching.

Unit IV: Photonic-Crystal Optics

Optics of Dielectric Layered Media: Matrix theory of multilayer optics, Bragg Grating. One-dimensional photonic Crystals - Bloch modes, dispersion relation and photonic band structure. Two- and three dimensional photonic crystals.

Reference Books:

1. Fundamentals of Photonics: B.E.A. Saleh and M.C. Teich
2. Photonics: Ralf Menzel
3. Quantum Electronics : A.Yariv
4. Nonlinear Optics : R.W. Boyd
5. Optics and Lasers : M.Young
6. Optical Electronics : A. Ghatak & K. Thyagarajan

Semester III

Choice Based Elective **General Relativity** **PHM-33E**

Unit I: Geometrical Basis

Vector and tensor fields, Affine connections, Metric tensor, Covariant derivative, Parallel transport Geodesic equation, Riemann curvature tensor. Symmetry properties of Riemann tensor. Bianchi identity. Ricci and Einstein tensor.

Unit II: Physics in Curved Spacetime

Equivalence Principle, Gravity as spacetime curvature, Weak gravitational field limit, Stress-energy tensor for a perfect fluid. Conservation equation for matter, Einstein equations (From Action Principle), Weak field limit of Einstein equations.

Unit III: Gravity in Simple Situations

Einstein equation in vacuum, Schwarzschild solution, Motion along a geodesic, Newtonian approximation, Gravitational redshift, Planetary motion and precession of the perihelion. Bending of light by a gravitating body.

Unit IV: Black Holes

Singularities in the Schwarzschild metric, Schwarzschild solutions in Kruskal-Szekeres coordinates. Gravitational collapse and black formation, Spherically symmetric collapse of dust, Reissner Nordstrom solution, Kerr solution.

Unit V: Cosmology

Cosmological principle; Robertson-Walker metric; Hubble's Law, Cosmological Redshift, Deceleration parameter, Distances, Cosmological fluid and its components, Matter conservation equation, Friedman Equation and Standard models, Closed, Flat and Open universe, Age of the universe.

Reference Books:

1. General Relativity : M.P.Hobson, G.P. Efstathiou and A.N.Lasenby
2. Gravitation and Cosmology : S.Weinberg
3. The Classical Theory of Fields: L.D.Landau and E.M.Lifshitz
4. Gravity: J.B.Hartle
5. Spacetime, Geometry and Gravitation : Pankaj Sharan

Semester III

Skill Enhancement Course | **Numerical Analysis And Programming** | **PHM-31A**

Unit I: Lab sessions

Sources of errors, propagation of errors in arithmetic operations, representation of numbers on computers, arithmetic of normalized floating point numbers, computer algorithm, Implementation of Numerical techniques using Fortran 2003/ANSI C.

Unit II: Solution of algebraic and transcendental equations

Chebyshev method, Steffensen method, Fixed point iteration, order of convergence, Singular Value Decompositions(SVD), eigenvalues and eigenvectors, Givens method and Householder method for symmetric matrices, QR Decompositional linear sparse systems, power method for finding extreme eigenvalues and eigenvectors; Maximization and minimization of functions.

Unit III: Interpolation and extrapolation

Lagrange's interpolation polynomial, Hermite Interpolation, Cubic spline interpolation, Fast Fourier Transform, Least square approximation, Approximation using orthogonal polynomials, Maximization for minimization of functions.

Unit IV : Differentiation and Integration

Differentiation based on Lagrange's Interpolation polynomial, two-point and three point formulae, Simpson's method, Romberg integration, Random number generator, Monte Carlo Integration; Gauss Quadrature: Legendre, Chebyshev, Hermite, Laguerre.

Unit V : Ordinary and partial differential equations

Ordinary differential equations, initial value problem, boundary value problem, Partial differential equations: parabolic, elliptic, hyperbolic; Finite Element Method(FEM)

Reference Books:

1. Numerical Analysis: C. F. Gerald, P. O. Wheatley
2. Numerical Analysis for Scientists and Engineers Theory and C Programs : Madhumangal Pal.
3. Fortran 95/2003 for Scientists and Engineers : Stephen J Chapman
4. Numerical Methods for Scientific and Engineering Computation : Jain, Iyengar and Jain
5. Numerical Analysis: Richard L Burden and J Douglas Faires
6. Computational Physics : J M Thijssen .
7. Numerical Recipes in C : The Art of Scientific Computing : Press, Teukolsky, Velleling and Flannery

Semester III

Physics Practical **Lab III** **PHM-31L**

List of Experiments :

1. Study of characteristics of a single mode optical fiber and determination of transmission losses.

2. Study of characteristics of a multi mode optical fiber and determination of transmission losses.

3. Determination of the (i) Rydberg constant using an optical grating and Hg lamp; (ii) H_2 and He spectral wavelengths.

4. Study of diffraction of light from a laser light source through a single slit using a photo-cell.

5. Determination of the specific charge of the electron by the Millikan's oil drop method.

6. Study of the Zeeman effect in Hg light spectra.

7. Study of electron diffraction upon transmission through a thin graphite film.

8. Study of diffraction and interference in microwaves.

9. Study of the characteristics and efficiency of a PEM fuel cell system.

10. Determination of the Curie temperature of ferromagnetic materials.

11. Study of a Fabry-Perot interferometer.

12. Study of radioactivity by using a G.M. tube to : (i) determine the range of α, β particles in air and (ii) absorption of γ radiation in various materials.

13. Study of energy storage using a solar thermal training system.

14. Study of solar photovoltaic cells (i) singly and (ii) in series and parallel configurations.

Semester IV

Core Course **Statistical Mechanics** **PHM-41C**

Unit I: Statistical basis of thermodynamics

The macroscopic and the microscopic states, phase space, trajectories and density of states, Liouville's theorem, ensemble theory, the principle of maximum entropy, contact between statistical mechanics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox

Unit II: Canonical and grand-canonical ensembles

Classical canonical ensemble, partition function, calculation of statistical quantities, Energy fluctuations. The grand canonical ensemble, particle number fluctuation. Entropy in grand canonical ensemble, thermodynamic potentials.

Unit III : Quantum Statistical Mechanics

Postulates of quantum statistical mechanics, density matrix, statistics of ensembles. Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.

Unit IV: Phase transitions

Type of phase transitions, first and second order phase transitions. Ising model, mean-field theories of the Ising model in two and three dimensions, exact solution in one dimension. Connection of Ising model to lattice gas and binary alloy models. Landau theory of phase transition, Landau free energy for second and first order transitions, critical exponents and universality classes.

Reference Books:

1. Statistical and Thermal Physics : F. Reif
2. Statistical Mechanics : K. Huang
3. Statistical Mechanics : R. K. Pathria
4. Statistical Mechanics: R. Kubo
5. Statistical Physics : Landau and Lifshitz
6. Thermodynamics and Statistical Mechanics : Greiner, Neise and Stocker
7. Statistical Physics : F. Mandl

Semester IV

Core Course **Condensed Matter Physics II** **PHM-42C**

Unit I: Interacting Electrons in Solids

Review of free electron theory, nearly free electron approximation, tight-binding model, LCAO approximation, Wannier functions, Hartree-Fock approximation, Dielectric constant of metals and insulators.

Unit II: Optical Properties

Electronic, interband and intraband transitions, relation between optical properties and band structure, reflectance, diffraction, dispersion, photoluminescence, electroluminescence, optical constants, Kramers-kronig relations, polarons, excitons, plasmons.

Unit III : Magnetism

Diamagnetism (including Landau diamagnetism) and Paramagnetism including van Vleck and Langevin paramagnetism), Exchange interaction of free electrons, Band model of Ferromagnetism, superexchange, double exchange, Hubbard model, Antiferromagnetism, Neel temperature, spin-waves, 2D electron gas in a magnetic field :Quantum Hall Effect. Landau levels. Degeneracy. Fractional quantum Hall effect.

Unit IV: Superconductivity and Superfluidity

Fundamental phenomena of superconductivity, Meissner effect, London equation, Type I and type II superconductors. Ginzburg-Landau Theory, Coopers pairing and BCS theory. BCS wave functions, Josephson Effect, SQUIDS. Weakly interacting Bose gas, Superfluidity.

Reference Books:

1. Introduction to Solid State Theory : O. Madelung
2. Solid State Physics : Ibach and Luth
3. Solid State Physics : Ashcroft and Mermin
4. Introduction to Solid State Physics : C. Kittel
5. Quantum Theory of Solid : C. Kittel
6. Many-Particle Physics (Physics of Solids and Liquids) : G.D. Mahan

Semester IV

Core Course **Physics & Technology of Semiconductor Devices** **PHM-43CM**

Unit I: MESFET and Related Devices

Metal-semiconductor contacts; Basic Characteristics, Schottky Barrier, Ohmic Metal Semiconductor Contact, Current Transport process, Determination of Barrier Height, MESFET; Device Structures, Principles of Operations, Current Voltage Characteristics, High Frequency Performance, MODFET or HEMT; fundamentals, , Current -Voltage Characteristics, Cut off Frequency.

Unit II: MOSFET and Related Devices

MOS Diode; SiO_2-Si MOS Diode, Charge Coupled Device (CCD), MOSFET Fundamentals; Basic Characteristics, Types of MOSFET, Threshold Voltage Control, MOSFET Scaling; CMOS and BiCMOS; MOS Memory Structures.

Unit III: Quantum Effect and Photonic Devices

Quantum-Effect Devices; Resonant Tunneling Diode, Unipolar Resonant Tunnelling Transistor, Semiconductor Laser; Semiconductor Materials, population Inversion at a junction, Emission spectra for p-n junction Lasers, Basic Laser Structure, Photodetector; Photoconductor, Solar Cell; p-n junction Solar cell, conversion Efficiency.

Unit IV: Film Formation and Epitaxial Growth

Thermal Oxidation; Dielectric Deposition; Thin Films Deposition Techniques: Thermal evaporation, Sputtering, Chemical Vapour Deposition(CVD), LPCVD, Epitaxial Growth Techniques: Vapour phase Epitaxy, Molecular Beam Epitaxy (Elementary description).

Unit V: Lithography, Etching and Diffusion of impurities

Optical Lithography; Exposure Tools, Masks, Photoresist, Electron Beam Lithography (Elementary description) ,Wet Chemical Etching, Dry Etching, Reactive Plasma Etching techniques and Equipment, Basic Diffusion Process: Diffusion Equations, Doping of Semiconductor.

Reference Books:

1. Semiconductor Devices Physics and Technology : S.M. Sze
2. Introduction to Semiconductor Devices: S.M. Tyagi
3. Physics of Semiconductor Devices : S.M. Sze,
4. Solid State Electronics : Ben G. Streetman
5. Material Science by Engineers : James F. Shackelford
6. The Physics of Semiconductor Devices : D.A. Eraser, Oxford Physics Series (1986)
7. Thin Film Phenomena : K.L. Chopra.
8. Semiconductor Physics and Devices : S.S.Islam

<u>Semester IV</u>

Core Course **Quantum Optics** **PHM-43CL**

Unit I: Quantum Theory of Radiation

Quantization of free electromagnetic fields, Fock states, Lamb shift, quantum beats, concept of photons, coherent and squeezed states of lights, quantum distribution theory and partially coherent radiation.

Unit II: Coherence and Light-matter interaction

First and second-order coherence, HBT effect, photon bunching and anti bunching, Poissonian and sub-poissonian light, photon counting and photon statistics, Atom- field interaction : semi classical theory and quantum theory, coherent trapping, electromagnetically induced transparency and lasing without inversion.

Unit III: Quantum theory of damping

Density operator method and Langevin approach, quantum theory of laser, squeezing of light in nonlinear optical process, Atom optics : mechanical effects of light, atomic interferometry, quantum noise in an atomic interferometer, limits to laser cooling.

Unit IV: Measurements in Correlated Quantum Systems

Introductory ideas on EPR paradox, Bells inequality, QND measurements and two photon interferometry

Reference Books:

1. Elements of Quantum Optics : Meystre and Sergent
2. Quantum optics : M.O. Scully and M.S. Zubairy
3. Optical coherence and quantum optics : Mandel and Wolf
4. Laser physics : Sargent, Scully and Lambs

Semester IV

Core Course **Particle Physics** **PHM-43CT**

Unit I: Invariance Principles and Symmetries

Charge conjugation, time reversal and parity , CPT theorem, Quark model and color and flavour quantum numbers, Weak isospin and hypercharge.

Unit II: Introduction to Gauge Theories

Abelian and non-abelian gauge theories, Spontaneous symmetry breaking, Goldstone theorem, Higgs phenomenon

Unit III: Standard Model

Historical introduction to Fermi theory and current algebra, Weinberg-Salam model, Basic Lagrangian, neutral current, GIM mechanism, KM matrix and CP violation.

Unit IV: Strong Interactions

Basic Lagrangian of QCD and its symmetries, Asymptotic freedom, Deep inelastic scattering

Unit V: Some Special topics

Anamolies, supersymmetry, string theory.

Reference Books:

1. Introduction to High Energy Physics : Perkins
2. Gauge Theory of Weak Interactions : Greiner & Muller
3. Gauge Theory and Particle Physics : Cheng Lee

Semester IV

Choice Based Elective **Physics of Novel Material** **PHM-41E**

Unit I: Quantum Well Structures

Electron confinement in infinitely deep square well, confinement in one and two dimensional well, idea of a quantum well structure, quantum dots, quantum wires

Unit II: Carbon nanotubes

Carbon nanotubes and other carbon materials, bonding between carbon atoms, single and multiwalled nanotube growth and characterization, electronic structure, crsytal structure, junctions and defects of nanotubes. Electronic structure, transport, optical properties, thermal and mechanical properties of nanotubes. Electron spectroscopy and scanning probe microscopy of nanotubes. Applications of carbon nanotubes.

Unit III : Non-carbon nanostructures

Semiconductor heterostructures, synthesis of nanomaterials using chemical techniques.

Unit IV: MEMS & NEMS

MEMS (microelectromechanical systems) and NEMS (nanoelectromechanical systems), nanomachines and applications.

Reference Books:

1. Quantum Dot Heterostructures : D. Bimberg, M.Grundman, N.N. Ledentsov
2. Carbon Nanotubes: Synthesis,Structure, Properties and Applications : M.S. Dresselhaus, G. Dresselhaus, Ph.Avouris
3. Electronics in Non-crystalline materials : Mott and Davis
4. Physics of Amorphous materials : Elliot
5. Superconductivity : A. V. Narlikar
6. Introduction to Solid State Theory : O. Madelung

Semester IV

Choice Based Elective **Laser Spectroscopy** **PHM-42E**

Unit I: Laser Spectroscopic Instrumentation

Monochromators. Interferometers. Laser detectors: Photocells, Photomultipliers, Photon Counters, Optical multichannel analyzer, Boxcar averager. Laser powers/Energy meters.

Unit II: Doppler-limited Spectroscopy with Laser

Advantages of Lasers in spectroscopy. Doppler-limited absorption spectroscopy: Excitation spectroscopy, Optoaccoustic spectroscopy, Intracavity absorption. Optogalvanic spectroscopy, Ionization spectroscopy. Laser induced fluorescence. Stepwise excitation. Spectroscopy of Rydberg states. Multiphoton spectroscopy.

Unit III: Nonlinear and Time resolved Spectroscopy

Doppler-free techniques in spectroscopy. Laser Raman spectroscopy: Stimulated Raman Scattering, Coherent Anti-stokes Raman spectroscopy(CARS), Experimental tehniques of Laser Raman spectroscopy, Applications of Laser Raman spectroscopy, Non-linear Raman spectroscopy. Time resolved Laser spectroscopy: Lifetime measurements with lasers.

Unit IV: Recent trends in Laser spectroscopy

Spectroscopy of single ions, Spectral resolution within the natural linewidth. Absolute frequency measurements and Optical frequency standards.

Reference Books:

1. Laser Spectroscopy : W. Demtroeder
2. Atomic and Laser Spectroscopy : A.Corney
3. Molecular and Laser Spectroscopy : Zu-Geng Wang, Hui-Rong Xia

Semester IV

Choice Based Elective **Quantum Field Theory** **PHM-43E**

Unit I: Canonical Quantization

Canonical quantization of neutral scalar, Charged scalar, spin 1/2 and massive spin-1 fields, Fock space and observables. Field commutation, anti-commutation relations.

Unit II: Interacting Fields

Interaction picture. Normal product. Wick's theorem. Feynman propagator. S-matrix. Feynman rules and diagrams

Unit III: Quantum Electrodynamics

Quantization of electromagnetic field. Gupta- Bleuler condition. Indefinite metric. Feynman diagrams of QED.

Unit IV: Scattering (tree level) in QED

Tree level calculations of Moller, Bhabha, Compton and Scattering in external field

Unit V: Some Special topics

1-loop corrections and renormalization. RG equations.

Reference Books:

1. Introduction to Relative Quantum Field Theory : S.S. Schwebber
2. Introduction to Quantized Field Theory : Bogoliubov & Shirkov
3. Relativistic Quantum Mechanics : Bjorken & Drell
4. Quantum Field Theory : Bjorken & Drell
5. Quantum Field Theory : Itzyksen & Zuber

<u>Semester IV</u>

Core Course **Project** **PHM-44C**

Guidelines for Project in M.Sc. Course :

1. Projects would be allotted to III Semester students which have to be carried out and completed in Semester IV.

2. The students will have an option to select the project in their field of interest. The projects shall be undertaken under the supervision of faculty within the department of physics or any other department / center of the university. In case the student wishes to work with a scientist in an institute outside Jamia Millia Islamia, she/he shall need to have a co-supervisor within the dept. of physics, Jamia Millia Islamia.

3. The project will comprise of the following:

- Survey and study of background literature material
- Experimental/analytical/computational research work, Collection of data, analysis of results.
- A dissertation or project report to be submitted by the end of the 4th semester.

4. The final evaluation of the completed project work will be based upon the work done, the submitted project report and an oral presentation.

JAMIA MILLIA ISLAMIA
(A Central University by an Act of Parliament)

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The Minutes of the Meeting of Board of Studies held on 07.05.2018 at 11.00 A.M.

A meeting of the Board of Studies (BoS) of the Department of Physics was held on 7th May, 2018 at 11.00 AM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. Zishan H. Khan (Department of Applied Science & Humanities)
Prof. M. Zulfequar
Dr. Asad Niazi
Dr. Azher Majid Siddiqui
Dr. Mohd. Shahid Khan
Dr. Anver Aziz
Dr. Arun Singh
Mr. Pumlian Monga
Dr. Somasri Sen
Dr. Javid Ali
Dr. Raza Shahid

1. The minutes of the last meeting of BoS held on 23/03/2018 were confirmed.
2. The changes in the Course structure of M.Sc. Physics as appended below were approved.

M.Sc. Physics (Semester - I) :

S.No.	Title of Paper	Paper type	Paper Code	Credit	Maximum Marks (Internal Assessment)	Maximum Marks (University Exam.)
	Quantum Mechanics - I	Core	PHM-11C	4	25	75
2.	Mathematical Physics - I	Core	PHM-12C	4	25	75
3.	Classical Mechanics	Core	PHM-13C	4	25	75
4.	Electronics (Choice Based Elective)	CBCS	PHM-11E	4	25	75
5.	Lab I	Lab.	PHM-11L	6	75	75

3	Particle Physics	Core	PHM 43CT	4	25	75
4	Project	Project	PHM 44C	6	75	75
	Electives					
1	Physics of Novel Materials	CBCS	PHM 41E	4	25	75
2	Laser Spectroscopy	CBCS	PHM 42E	4	25	75
3	Quantum Field Theory	CBCS	PHM 43E	4	25	75

3. The distribution of theory courses for M.Sc. (Physics) and B.Sc. (H/P/S) for odd semesters for the Session 2018-2019 was approved.

4. The introduction of B.Voc. (Solar Energy) in Self Financing mode from the Academic Session 2018-2019 was also approved.

The meeting ended at 12.30 P.M. with thanks to the Chair.

(Dr. Saeed Uddin)
Professor & Head

Professor & Head
Department of Physics
Jamia Millia Islamia
New Delhi-110025