Parvatibai Chowgule College of Arts and Science
Autonomous
Accredited by NAAC with Grade 'A' (CGPA Score 3.41 on a 4 Point Scale)
Best affiliated College-Goa University Silver Jubilee Year Award

F.133C//023

October 22 ,2016

All the members of the Board of studies in Physics

Sub: Minutes of the Third meeting of the Board of studies in Physics held on 8Th October, 2016

Sir/Madam,

I am forwarding the minutes of the third BoS in Physics meeting held on October 8, 2016 at the Parvatibai Chowgule College of Arts and Science(Autonomous) , Margao. If no exception is taken by any members of BOS to the correctness of the meeting within 5 days of the dispatch of the minutes, they shall be deemed to be correct.

Yours sincerely,

Ananya Das

Dr. Ananya Das
Chairman
Board of Studies in Physics

Encl: Minutes of the Meeting.

Parvatibai Chowgule College of Arts & Science
(Autonomous)
Margao – Goa

MINUTES OF THIRD MEETING OF THE BOARD OF STUDIES IN PHYSICS HELD ON 8th October 2016 AT 10:30 am

Vide Chowgule College notice (F.133(C)/865 dated 23rd September, 2016) a meeting of this BoS was convened on 8th October, 2016 at 10:30 am at the Conference Room, Parvatibai Chowgule College of Arts & Science, Margao – Goa. Since the members present represented the Quorum, the BoS began its proceedings.

Minutes are presented in the format.

Members present:

1. Dr. Ananya Das (Chairman)
2. Mrs. Malati Dessai
3. Mr. Yatin Desai
4. Mrs. Pallavi Dalvi
5. Prof. Kaustubh Priolkar (Academic Council Nominee)
6. Prof. A.V. Kulkarni (Academic Council Nominee)
7. Dr. Ashish M. Desai (Member Secretary)

Members Absent

1. Dr. Preeti Bhobe (Vice-Chancellor Nominee)
2. Mr. Pramod Maurya (Industry Representative)
3. Mr. Deepak Kumar (Postgraduate Alumni)

Proceedings

The Chairperson welcomed the members of the Board of Studies (BoS) and briefed the minutes of the second BoS meeting held on 10th October 2015. The Chairperson introduced and explained the agenda for the meeting and Board transacted the following business:

Agenda Items:

1. To discuss and approve the modified list of core and elective courses for the undergraduate program in Physics.
2. To discuss and approve the syllabi of Semester V and Semester VI for the academic year 2017-18.
3. Any Other Business (A.O.B.)

PART A: Resolutions

1. The BoS passed the following resolutions with respect to titles of core and elective courses.
    i. The course entitled "Introduction to Physical Oceanography" replaced by "Mathematical Physics".
    ii. The course entitled "Solid State Physics" (Core course for students opting for Physics as their minor subject) replaced by "Statistical Physics and Solid State Physics".
    iii. The course entitled "Introduction to Astronomy and Astrophysics" to be added as an elective course in Semester VI.

2. The list of courses for the undergraduate program in Physics were discussed and modified. The revised list approved by the members of BoS is presented in Annexure I.

3. The syllabi of undergraduate courses were presented and discussed at the meeting. After minor changes, the members of BoS approved the syllabi of the courses for Semester V and VI. The approved syllabi of Semester V and Semester VI are presented in Annexure II.

4. Under A.O.B of the agenda, the members had a discussion on the guidelines for the internship in Physics. Keeping in mind the guidelines for the Internship program and the requirements to be met by students, the refresher courses in theoretical/experimental physics of two weeks duration organized by Indian Academy of Sciences, followed by two weeks of internship in the Department of Physics was approved by the members of BoS as a completion of Internship program in the subject of Physics.

PART B: Resolutions/Recommendations of BoS that require consideration / approval of Academic Council:

1. The list of core and elective courses presented in Annexure I.
2. The syllabi of Semester V and Semester VI presented in Annexure II.
3. The Refresher courses in theoretical/experimental physics of two weeks duration organized by Indian Academy of Sciences, followed by two weeks of internship in the Department of Physics as a completion of Internship program in the subject of Physics.

The Chairman thanked the members of Board of Studies in Physics for their valuable contribution and active participation. The meeting ended at 2:00 pm.
The foregoing minutes of the meeting are circulated by the Chairman on 22nd October, 2016.

Dr. Ashish M. Desai
Member Secretary
BoS (Physics)
Date: 22nd October, 2016

Ananya Das
Dr. Ananya Das
Chairman
BoS (Physics)

PART C: The remarks of the Dean of the Faculty:-

a. The minutes are in order

b. The minutes may be placed before the Academic Council with remark, if any.

c. Important points of the minutes which need clear policy decision of the Academic council to be recorded.

Date: 1|11|2016

Signature of the Dean: Ananya Das
(Faculty of Science) (Dr. Ananya Das)

Annexure I

Core Courses in Physics (Major)

Sr. No	Semester	Title of the Paper	Code
1	I	Introduction to Mathematical Physics	PHY-I.C-1
2	I	Mechanics-I	PHY-I.C-2
3	II	Heat and Thermodynamics	PHY-II.C-3
4	II	Electricity and Magnetism	PHY-II.C-4
5	III	Electromagnetic Theory-I	PHY-III.C-5
6	IV	Quantum Mechanics	PHY-IV.C-6
7	V	Electromagnetic Theory-II	PHY-V.C-7
8	VI	Atomic and Molecular Physics	PHY-VI.C-8

Elective Courses in Physics (Major)

Sr. No.	Semester	Title of the Paper	Code
1	III	*Optics	PHY-III.CE-1
2	III	Modern Physics	PHY-III.CE-2
3	III	Oscillations, Waves and Sound	PHY-III.CE-3
4	III	Properties of Matter and Acoustics	PHY-III.CE-4
5	IV	*Electronics-I	PHY-IV.CE-5
6	IV	Solid State Devices	PHY-IV.CE-6
7	IV	Computational Physics	PHY-IV.CE-7
8	IV	Instrumentation	PHY-IV.CE-8
9	V	*Solid State Physics	PHY-V.CE-9
10	V	Thermodynamics and Statistical Mechanics	PHY-V.CE-10
11	V	Electronics-II	PHY-V.CE-11
12	V	Mathematical Physics	PHY-V.CE-12
13	VI	*Mechanics II	PHY-VI.CE-13
14	VI	Nuclear and Elementary Particle Physics	PHY-VI.CE-14
15	VI	Introduction to Special Theory of Relativity	PHY-VI.CE-15
16	VI	Introduction to Material Science	PHY-VI.CE-16
17	VI	Introduction to Astronomy and Astrophysics	PHY-VI.CE-17

*****BoS Physics recommends these elective courses to be taken by students as a prerequisite to the M.Sc. (Physics) Program.

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Core Courses in Physics (Minor)

Sr. No.	Semester	Title of the Paper	Code
1	I	Mechanics, Properties of Matter and Sound	PHY-I.MI-1
2	II	Electricity, Magnetism and Electronics	PHY-II.MI-2
3	III	Elementary Modern Physics	PHY-III.MI-3
4	IV	Heat and Optics	PHY-IV.MI-4
5	V	Statistical Physics and Solid State Physics	PHY-V.MI-5
6	VI	Atomic and Nuclear Physics	PHY-VI.MI-6

Note: Courses listed above are of 3 credits of Theory (45 Contact Hours) and 1 credit of Practical (15 sessions, each session of 2 Contact Hours).

Annexure II

ParvatibaiChowgule College of Arts and Science (Autonomous)
Margao, Goa

Syllabus for

Semester-V and Semester-VI

of the undergraduate degree courses

in

Physics

(2017-2018)

Core and Elective Courses for students taking Physics as their Major subject.

Semester V

1. Electromagnetic Theory-II
2. Solid State Physics
3. Thermodynamics and Statistical Mechanics
4. Electronics-II
5. Mathematical Physics

Semester VI

1. Atomic and Molecular Physics
2. Mechanics II
3. Nuclear and Elementary Particle Physics
4. Introduction to Special Theory of Relativity
5. Introduction to Material Science
6. Introduction to Astronomy and Astrophysics

Paper Title: Electromagnetic Theory – II

Paper Code: PHY-V.C-7

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Contact Hours: 45 (Theory) + 30 (Practical)

Course Objectives: To acquaint students with fundamental principles of Magnetostatics part of the Electromagnetic Theory.

Learning Outcome: At the end of this course, students would be able:

a) to calculate magnetic field using Biot-Savart law and Ampere's law.
b) understand the link between electrostatics and magnetostatics using Maxwell's equations.
c) learn about the propagation of electromagnetic waves.

Pre-requisite: Electromagnetic Theory – I (PHY-III.C-5)

Theory:

1. Magnetostatics **[12L]**

Lorentz force law: Magnetic fields, Magnetic forces, Currents, Biot-Savart law: Steady currents, Magnetic fields of a steady current, Divergence and Curl of **B**: Straight-line currents, divergence and curl of **B**, applications of Ampere's law, comparison of magnetostatics and electrostatics, Magnetic vector Potential: Vector potential, magnetostatic boundary conditions, multipole expansion of the vector potential.
[Griffiths: 5.1: 5.1.1 – 5.1.3, 5.2: 5.2.1 – 5.2.2, 5.3: 5.3.1 – 5.3.4, 5.4: 5.4.1 – 5.4.3]

2. Magnetic Fields in Matter **[14L]**

Magnetization: Diamagnets, paramagnets and ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization, the field of a magnetized object: Bound currents, physical interpretation of bound currents, magnetic field inside matter, The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions, Linear and nonlinear media: Magnetic susceptibility and permeability, Energy in magnetic fields.
[Griffiths: 6.1: 6.1.1 – 6.1.4, 6.2: 6.2.1 – 6.2.3, 6.3: 6.3.1 – 6.3.3, 6.4: 6.4.1 – 6.4.2, 7.2.4]

3. Microscopic Theory of Magnetism **[5L]**

Molecular field inside matter, origin of diamagnetism, origin of paramagnetism, theory of ferromagnetism, ferromagnetic domains, ferrites
[Reitz: 10.1 – 10.2]

4. Maxwell's Equations **[4L]**

Generalization of Ampere's law, displacement current, Maxwell's equations and their ampirical basis, electromagnetic energy, Poynting theorem.

[Reitz: 16.1 – 16.3]

5. Propagation of Electromagnetic Waves **[10L]**

The wave equation, plane monochromatic waves in non-conducting media, polarization, plane monochromatic waves in conducting media, reflection and refraction at the boundary of two non-conducting media: normal incidence and oblique incidence, Brewster's angle, critical angle.

[Reitz: 16.4, 17.1, 17.2, 17.4, 18.1, 18.2]

Experiments: (Minimum Six)

1. Hysteresis by magnetometer.
2. B-H curve in a hard magnetic material and in a soft ferrite.
3. Core losses and copper losses in a transformer.
4. Measurement of mutual inductance using ballistic galvanometer.
5. Calibration of lock-in-amplifier and determination of mutual inductance.
6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method.
7. M/C using ballistic galvanometer

References:

1. Griffiths D. J., 2011, *Introduction to Electrodynamics,* 3rd Ed. , Prentice Hall of India.

2. Reitz J. R., Milford F. J., Christy R. W., 1979, *Foundations of Electromagnetic Theory*, 3rd Ed., Addison-Wesley Publishing Company.

Additional Reference:

1. Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.

Paper Title : **Solid State Physics**

Paper Code : **PHY-V.CE-9**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Course Objective: To give the students a firm understanding of the basics of Solid State Physics. The course broadly deals with the topics related to structural aspects and the various physical properties of crystalline solids.

Learning Outcome: After completion of this course, students will develop a comprehensive broad knowledge in topic such as: Bondings in Solids, Crystal Physics, Electrical properties of solids, Origin of energy band structure in solids and Magnetic properties of materials.

Pre-requisites: Modern Physics and Quantum Mechanics

Theory:

1. Bonding in Solids: **[5 L]**

Introduction, Bonding in Solids, Cohesive energy, Ionic bonding, Calculation of Cohesive energy of ionic solids, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.

[Palanisamy: 1.1, 1.2, 1.3, 1.4, 1.4.1, 1.5 - 1.5.2, 1.6 - 1.9]

2. Crystal Structure: **[12 L]**

Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures, Crystal structures- NaCl, diamond, CsCl, ZnS, Directions in crystals, Planes in crystals- Miller indices, Distances of Separation between Successive (*hkl*) Planes.

[Palanisamy: 2.1, 2.2 - 2.2.3, 2.3 - 2.3.4, 3.1, 3.2, 3.3 -3.3.2, 3.4]

3. Diffraction of X-rays by Crystals: **[5 L]**

Introduction, Bragg's law, Production of X-rays, Determination of lattice parameters and X-ray Diffraction methods: Laue method and Debye Scherrer method.

[Palanisamy: 4.9 - 4.9.3, 4.10 - 4.10.2]

4. Electron Theory of Metals: **[18 L]**

Introduction, Classical free electron theory, Quantum theory of free electrons, Fermi distribution function, Density of energy states, Sources of electrical resistance, Electrons in a periodic potentials, Energy bands in Solids.

[Palanisamy: 6.1, 6.2 - 6.2.2, 6.3, 6.3.1, 6.4, 6.5, 6.6, 6.7-6.7.5, 6.8]

5. Magnetic Properties: **[5 L]**

Introduction, Classification of magnetic materials, The quantum numbers, Origin of magnetic moment, Ferromagnetism, Ferromagnetic domains, Hysteresis, Hard and soft materials.

[Palanisamy: 8.1, 8.2, 8.3, 8.4, 8.7, 8.7.3, 8.7.5, 8.7.6]

Experiments: (Minimum Six)

1. Energy band gap of a semiconductor
2. Energy band gap of LEDs
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. Fermi energy of Copper
5. Measurement of Hysteresis loss using CRO
6. Calculation of lattice constant by of Copper – X-ray diffraction pattern is given and student calculates: d-spacing, miller indices and lattice constant
7. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap

References:

1. Palanisamy P. K., 2004, *Solid State Physics,* Scitech Publications (India) Pvt. Ltd.
2. Pillai S. O., 1999, *Solid State Physics*, 3rd Edition, New Age International (P) Ltd, Publisher.
3. Kittel C., 2004, *Introduction to Solid State Physics*, 8th Edition,John Wiley and Sons.
4. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.

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Paper Title : **Thermodynamics and Statistical Mechanics**

Paper Code : **PHY-V.CE-10**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Pre-requisite: PHY-II.C-3

Course Objectives: Topics covered include Power cycles, conversion of heat into useful work, phase transitions, classical and quantum distribution.

Learning Outcome: After completion of this course students will be able to understand applications of thermodynamics and statistical mechanics such as description of system involving many particles.

Theory

1. **Thermodynamic Potentials** **[4 L]**
   The Helmholtz function and Gibbs function, Thermodynamic Potentials, Maxwell Relations.
   [Ref#5 Section 7.1-7.3]

2. **Production of low temperature.** **[18 L]**
   Cooling by evaporation. Vapour compression machines. Refrigerators based on Vapour absorption. Cooling by sudden adiabatic expansion of compressed gases. Efficiency and performance of Refrigerating machines. Enthalpy and heat flow. Joule Kelvin effect. Expression for joule Kelvin coefficient and inversion temperature. Van der Waals' gas. Principles of regenerative and cascade cooling. Liquifaction of hydrogen and helium. Production of temperatures below 4 K. Properties of He I and He II. Cooling by Adiabatic Demagnetisation of paramagnetic substances.
   [Ref#1 Section 7.3,7.4,7.7,7.9,7.10-7.18 Ref#2 section 12.1-12.10]

3. **Probability** **[11 L]**
   Random Events, Probability, Probability and Frequency, Some basic rules of Probability theory, Continuous random variables, Mean value of discrete and continuous variables, Variance: Dispersion, Probability Distribution, Binomial distribution: Mean value and fluctuation, Stirling's Approximation, Poisson Distribution: Mean value and Standard deviation, Gaussian Distribution: Standard deviation, Random Walk.
   [Ref#1 Section 9.1-9.10 Ref# 2 pp 5-16]

4. **Statistical Thermodynamics** **[12L]**
   Phase space, Macrostate and Microstate, Maxwell Boltzman Statistics. Molecular speeds: mean, most probable and rms speeds. Experimental verification of Maxwell Boltzman statistics. Statistical interpretation of Entropy, Quantum statistics: Bose Einstein and Fermi Dirac distribution law.
   [Ref#1 Section 11.4-11.6, 10.15, 10.21, 12.5-12.8 Ref# 4 15.1-15.6, 16.1, 16.5]

Experiments: (Minimum Six)

1. Specific heat of Graphite
2. Study the temperature dependence of resistivity.
3. OPAMP as a bridge amplifier and its application in temperature measurement
4. Determination of Boltzmann constant
5. Tutorial on Maxwell Equation and Free enrgy
6. Tutorial on Probability
7. Tutorial on Probability
8. Tutorial on Statistical Thermodynamics
9. Tutorial on Statistical Thermodynamics

References:

1. Brijlal, Subrahmanyam N., 2008, *Heat thermodynamics and Statistical Physics*, S Chand Company Ltd.
2. Laud B., 2003, *Introduction to Statistical Mechanics*, New Age International.
3. Saha M. and Shrivastava B., 1965, *Treatise on heat*, The Indian Press.
4. Beiser A., 1995, *Perspectives of modern physics*, 5th edition, McGraw hill.
5. Sears F. and Salinger G., 1998, *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, 3rd Edition, Narosa.

Additional References:

1. Garg S., Bansal R.and Ghosh C., 1993, *Thermal Physics*, Tata McGraw Hill.
2. Zemansky M. and Ditman R., 1997, Heat *and Thermodynamics*, McGraw Hill.
3. Reif F., 1965, *Fundamentals of Statistical and Thermal Physics*, Mc Graw Hill

Paper Title : **Electronics-II**

Paper Code : **PHY-V.CE-11**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Pre-requisite: PHY-IV.CE-5

Course Objectives: This course aims at introducing students to analog and digital circuits.

Learning Outcome: After completion of this course, students will understand the analysis of AC circuits and will be able to apply these techniques in designing circuits.

Theory

1. **AC Models (BJT)** **[4 L]**
   Base-Biased amplifier, Emitter-Biased amplifier, Small signal operation, analyzing an amplifier.
   [Ref.# 1 Article 9.1 to 9.7]

2. **Transistor Multivibrators** **[4 L]**
   Transistor as a switch, switching times, Multivibrators – Astable, Monostable, Bistable and Schmitt Trigger.
   [Ref.# 3 Article 18.1 to 18.5]

3. **FET's and MOSFET's** **[9 L]**
   Basic structure of the JFET, Principles of operation, Characteristic curves and parameters, Common source amplifiers, Common gate amplifier,
   MOSFET: Depletion Mode and Enhancement mode, Dual-Gate MOSFET.
   FET Phase shift oscillator, FET as VVR and its applications in Attenuator, AGC and Voltmeter circuits.
   [Ref.# 1 Article 13.1 to 13.9, 14.1 to 14.5]

4. **OPAMP Applications** **[4 L]**
   Active diode circuits, Comparator, Window comparator, Schmitt Trigger, Waveform generator –Square wave, Triangular and Ramp Generator and monostable.
   [Ref. #1 Article 22.7, 22.8]

5. **Timers** **[4 L]**
   The 555 Timer, Basic concept, 555 block diagram, Monostable, Astable, Bistable, Schmitt Trigger and Voltage controlled oscillator (VCO) using 555 timer.
   [Ref.# 1 Article 23.7, 23.8]

6. **Monolithic Linear Regulators** **[3 L]**
Basic type of IC regulator, Load and line regulation, LM7800 series,Current Boosters,LM-317 or LM7812 as a voltage regulator.
[Ref#4 24.4,24.5]

7. **Digital Circuits** **[8 L]**
Binary number system, Binary to Decimal and Decimal to Binary conversion, Basic logic gates, AND, OR, NOT (realization using Diodes and Transistor), NAND, NOR as universal building blocks in logic circuits, EX-OR and Ex-NOR gates.
Boolean Algebra:De Morgan's Law's, Boolean Laws, NAND and NOR gates, Sum of Products methods and Product of Sum methods of representation of logical functions. Half adder and Full adder,
Data Processing Circuits: Multiplexer and Demultiplexer, Encoders and decoders.
[Ref. # 2 Article5.1 to 5.8.1, 6.1, and 6.2]

8. **Sequential Circuits** **[9 L]**
Basic RS FF, Clocked RS FF, JK FF, D-type and T-type FF, Master Slave Concept.
Shift Registers: Serial-in-Serial-Out, Serial-in-Parallel-out, Parallel-in-Serial-out, Parallel-in-Parallel-out Shift registers (upto 4 bits)
Counters: Applications of FF's in counters, binary ripple counter, Modulus of counter (3,5) BCD Decade Counter, Cascade BCD Decade counters.
[Ref.# 2 Article7.1 to7.9, 8.1, 8.2, 8.4]

Experiments (Minimum Six):

1. Astable Multivibrator
2. Monostable Multivibrator
3. Bistable Multivibrator
4. Schmitt Trigger
5. F.E.T Characteristics
6. Op-Amp As A Bridge Amplifier And Its Application In Temperature Measurement
7. IC Lm 317 Voltage Regulator
8. IC 555 Timer As Astable Multivibrator And Its Use As Voltage Controlled Oscillator
9. IC 555 Timer As Monostable Multivibrator
10. Digital Multiplexer
11. Verification Of De Morgan’s Theorems And Boolean Identities
12. Nand And Nor Gates As Universal Building Blocks
13. Binary Addition –Half Adder And Full Adder Using Gates

References :

1. Malvino A., 1996, *Electronic Principles*, 5^{th} edition, Tata McGraw Hill.
2. Jain R. P. 2003, *Digital Electronics*, 3^{rd} edition, Tata McGraw Hill.
3. Mottershed A. 1997, *Electronics Devices and Circuits an Introduction*, PHI
4. Malvino A. and Bates D.J., 2007, *Electronic Principles*, 7th edition, Tata McGraw Hill

Additional References:

1. Malvino A. and Leach D. 1986, *Digital Principles and Applications,* 4th edition Tata McGraw Hill.
2. Millman J. and Halkias C., 1972, *Intergrated Electronics*, Tata McGraw Hill.
3. Millman J. and Halkais C., 1967, *Electronic Devices and Circuits,* Mc Graw Hill.
4. Mehta V.K., 2003, *Principles of Electronics*, 8th edition, S.Chand & Company.

Paper Title: Mathematical Physics

Paper Code: PHY-V.CE-12

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Contact Hours: 45 (Theory) + 30 (Practical)

Course Objectives: To acquaint students with mathematical skills which are required to study various concepts of Physics.

Learning Outcome: At the end of this course, students would be able to apply mathematical techniques such as: calculus of residues, solutions of Legendre, Bessel and Hermite equations, Fourier transforms of different functions in solving various Physics problems.

Pre-requisite: Introduction to Mathematical Physics (PHY-I.C-1)
Theory:

1. **Functions of a Complex Variables** **[8 L]**

Introduction, complex variables and representations: algebraic operations, Argand diagram: vector representation, complex conjugate, Euler's formula, De Moivre's theorem, the n^{th} root or power of a complex number, analytic functions of a complex variable: the derivative of f(z) and analyticity, harmonic functions, contour integrals, Cauchy's integral theorem, Cauchy's integral formula.
[Harper: 3.1, 3.2: 3.2.1 – 3.2.6, 3.3: 3.3.1 – 3.3.5]

2. **Calculus of Residues** **[8 L]**

Zeroes, isolated singular points, evaluation of residues: m^{th} order pole, simple pole, the Cauchy residue theorem, the Cauchy principal value, evaluation of some definite integrals.
[Harper: 4.1 – 4.3: 4.3.1 – 4.3.2, 4.4 – 4.6: 4.6.1-4.6.4]

3. **Partial Differential Equations and Special Functions of Mathematical Physics** **[14 L]**

Introduction,Some important partial differential equations in physics, an illustration of the method of direct integration, method of seperation of variables, the Hermite polynomials: basic equations of motion in mechanics, one-dimensional linear harmonic oscillator, solution of Hermite's differential equation, Legendre and associate Legendre polynomials: spherical harmonics, the azimuthal equation, Legendre polynomials, Bessel function: introduction: solution of Bessel's equation, analysis of various solutions of Bessel's equation, characteristics of Bessel functions.
[Harper: 6.1 – 6.5: 6.5.1 – 6.5.3, 6.5.8]

4. Fourier Series **[7 L]**

Introduction: The Fourier cosine and sine series, change of interval, Fourier integral, complex form of Fourier series, generalized Fourier series and Dirac-delta function, summation of the Fourier series.

[Harper: 7.1 – 7.3]

5. Fourier Transforms **[8 L]**

Introduction, theory of Fourier transforms: formal development of the complex Fourier transform, cosine and sine transforms, multiple-dimensional Fourier transforms, the transforms of derivatives, the convolution theorem, Parseval's relation, the wave packet in quantum mechanics: origin of the problem - quantization of energy, the development of a new quantum theory, a wave equation for particles - the wave packet.

[Harper: 8.1 – 8.3]

Experiments: (Minimum Six)

1. Generating and plotting Legendre Polynomials.
2. Generating and plotting Bessel function.
3. Generating and plotting Hermite Polynomials.
4. Using spherical polar co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
5. Using cylindrical co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
6. Fourier series: programme to sum:$\sum_{n=1}^{\infty}(0.2)^n$, and to evaluate Fourier co-efficients of a given periodic functions.
7. Compute the n^{th} roots of unity for *n* = 2, 3, and 4.

References:

1. Harper, C., 1993, *Introduction to Mathematical Physics*, 5^{th} Ed. , Prentice Hall of India,.
2. Arfken G., 2005, *Mathematical Methods for Physicists*, Elsevier.
3. Spiegel, M.R., 2004, *Fourier Analysis*, Tata McGraw-Hill.

Additional References:

1. Riley K. F., Hobson M. P., Bence S. J., 1998, *Mathematical Methods for Physics and Engineering*, Cambridge University Press
2. Boas M. L., 2013, *Mathematical Methods in Physical Sciences*, John Wiley and Sons, 3^{rd} Ed.
3. Lipschutz S., 1974, *Schaum Outline of Theory and Problems of Complex Variables*, Mc Graw Hill.

Paper Title : Atomic and Molecular Physics

Paper Code : PHY-VI.C-8

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Contact Hours : 45 (Theory) + 30 (Practical)

Pre-requisite: Quantum Mechanics (PHY-IV.C-6)

Course Objectives: Atomic and molecular physics is the study of dynamics and interactions of the basic building blocks of matter. The objective of this course is to study the behaviour of the electrons that surround the atomic nucleus which will help students to understand the dynamics atoms and molecules.

Learning outcome: After successful completion of this course, student will be able to understand the atomic structure, and dynamics of atoms and molecules. They will also gain insight to the physics of atomic and molecular spectral lines.

Theory:

1. **Quantum Theory of the Hydrogen Atom**: **[6 L]**
   Schrodinger's equation for the H-atom. Separation of variables, Eigen values, Quantum numbers and Magnetic moment. Angular momentum, Electron Probability density.
   [Beiser 9.1-9.9]

2. **Many Electron Atoms: [7 L]**
   Electron Spin.. Pauli Exclusion Principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions. Electron configuration. Hund's rule. Total angular momentum. L-S coupling. J-J coupling.
   [Beiser 10.1, 10.3- 10.9]

3. **Atoms in a Magnetic Field: [7 L]**
   Effects of magnetic field on an atom. Larmor Precession. The Stern-Gerlach experiment. Spin Orbit Coupling. The Normal Zeeman effect, Lande 'g' factor. Zeeman pattern in a weak field (Anomalous Zeeman effect).
   [Eisberg 8.1-8.4, 10.6]

4. **Atomic Spectra: [4 L]**
   Origin of Spectral lines. Selection rules (derivation from transition probabilities). Alkali metal type spectra. Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra.
   [Beiser 11.1-11.2, Mcgervey 9.1]

5. **X-ray Spectra: [4L]**

Characteristic spectrum. Moseley’s law. Explanation of X-ray spectra on the basis of quantum mechanics. Energy levels and characteristic X-ray lines. X-ray absorption spectra. Fluorescence and Auger effect.
[Richtmayer: 7.6, 7.7, 16.1-16.3, 16.5]

6. **Spectra of Diatomic Molecules:** **[10L]**
   Rotational energy levels. Rotational spectra. Vibrational energy levels. Vibration - Rotation spectra. Fortrat Parabolas and explanation of band structure on its basis. Electronic spectra.
   [Beiser 14.1, 14.3, 14.5, 14.7, 14.8 and Rajam 11.2]

7. **Raman Effect:** **[7L]**
   Quantum theory of Raman effect. Classical theory of Raman effect. Pure rotational Raman spectra. Vibrational Raman spectra. Rotational fine structure. Experimental set up for Raman effect.
   [Banwell 4.1-4.3]

Experiments: (Minimum Six)

1. Absorption spectra of $KMnO_4$
2. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy.
3. Resolving Sodium D-lines using grating.
4. Resolving Mercury lines using prism.
5. Determination of wavelength of Sodium light using Lloyd’s Mirror.
6. Determination of wavelength of Sodium light using a cylindrical obstacle.
7. Double Refraction

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.
3. Mcgervey, J. 1983, *Introduction to Modern Physics*, Academic Press, USA.
4. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
5. Rajam, J. 2000, *Atomic Physics*, S. Chand and Company limited, New Delhi.
6. Banwell, C. 1994, *Fundamentals for Molecular Spectroscopy*, 4th Edition, McGraw-Hill Higher Education.

Additional References:

1. White, H. 1934, *Introduction to Atomic Spectra*, McGraw-Hill Inc., USA.

Paper Title	**:**	**Mechanics – II**
Paper Code	**:**	**PHY-VI.CE-13**
Marks	**:**	**75 (Theory) + 25 (Practical)**
Credits	**:**	**3 (Theory) + 1 (Practical)**
Contact Hours	**:**	**45 (Theory) + 30 (Practical)**

Course Objectives: To acquaint students with a higher level Mechanics which includes advanced concepts through topics like central force problems, mechanics in non inertial frames, motion of rigid bodies, collision theory and Langrangian formulation.

Learning Outcome: At the end of this course students will be able to comprehend and relate advanced concepts in Mechanics.

Pre-requisite **:** Mechanics – I

Theory

1. **Two-Body Central-Force Problems** **[9 L]**
   CM and Relative Coordinates; Reduced Mass, The Equations of Motion, The Equivalent One-Dimensional Problem, The Equation of Orbits, The Unbounded Kepler Orbits, Changes of Orbits
   [Ref. No. 1 pp. 293 – 315]

2. **Mechanics in Non-inertial Frames** **[9 L]**
   Acceleration without Rotation, The Tides, The Angular Velocity Vector, Time Derivatives in a Rotating Frame, Newton's Second Law in Rotating Frame, The Centrifugal Force, The Coriolis Force, Free Fall, Projectile motion and the Foucault Pendulum.
   [Ref. No. 1, pp. 327 – 358]

3. **Rotational Motion of Rigid Bodies** **[10 L]**
   Properties of the Center of Mass, Rotation about a Fixed Axis, Rotation about Any Axis, the Inertia Tensor, Principal Axis of Inertia, Finding the Principal Axis; the Eigenvalue Equations, Precession of a Top due to a Weak Torque, Euler's Equations, Euler's Equations with Zero Torque, Euler Angles, Motion of Spinning Top
   [Ref. No. 1 pp. 367 – 403]

4. **Collision Theory** **[7 L]**
   The Scattering Angle and Impact Parameter, The Collision Cross Section, Generalizations of the Cross Section, Differential Scattering Cross Section and its Calculations Rutherford Scattering
   [Ref. No. 1 pp. 557 – 582]

5. **Lagrange's Equations** **[10 L]**

Constraints, Generalised coordinates, D'Alembert's Principle. Lagrange's Equations, A general expression for kinetic energy, Symmetries and laws of conservation. Cyclic or ignorable coordinates

[Ref. No. 1 pp. 237 – 275 and Ref. No. 2 Section 8.1-8.7]

List of Experiments: (Minimum Six)

1. Study of Compound Pendulum as a Reversible Pendulum: Kater's Pendulum
2. Measurement of Moment of Inertia of Uniform Rigid Bodies: Bifilar Suspension
3. Principle of conservation of linear momentum using linear air track
4.Value of "g" by Rod pendulum
5.To Study the different oscillation modes of the coupled pendulum
6.To determine the moment of inertia of Gyroscope disc
7. Equation of Orbit (bounded orbit) simulation experiment
8. Equation of Orbit (unbounded orbit) simulation experiment

References:

1. Taylor J. R., 2005, *Classical Mechanics*, University Science Books.
2. Takwale R. G., and Puranik P. S., 1992, *Introduction to Classical Mechanics*, Tata Mc-Graw Hill

Additional Reference:

1. Symon K. R., 1971, *Mechanics*, Addison Wesley

Paper Title : Nuclear and Elementary Particle Physics

Paper Code : PHY-VI.CE-14

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Contact Hours : 45 (Theory) + 30 (Practical)

Pre-requisite : Quantum Mechanics (PHY-IV.C-6)

Course objectives: The objective of this course is to introduce students to the fundamental principles and concepts governing nuclear and particle physics.

Learning outcome: After successful completion of this course, student will be able to understand the fundamental principles governing the basic properties of nuclei, nuclear structure and particle physics. Students will also be able to solve elementary problems, relating theoretical predictions and measurement results, in nuclear and particle physics.

Theory:

1. **Constituents and properties of the Nucleus: [4 L]**
   Measurement of Nuclear Radius. Nuclear spin. Magnetic dipole moment. Electric Quadrapole moment. Parity. Binding energies and a plot of B/A against A.
   [Patel: 4.1.3, 4.1.5, 1.2.4, 5.2]

2. **Nuclear forces: [3 L]**
   Main characteristics of Nuclear Forces. Meson theory of Nuclear forces, Estimation of the mass of a meson using Heisenberg's Uncertainty Principle, Yukawa potential.
   [Patel: 8.6]

3. **The Q Equation**: **[4 L]**
   Types of Nuclear Reaction, The Balance of mass and energy in Nuclear reaction, The Q Equation.
   [Patel: 3.2, 3.3, 3.4]

4. **Radioactive decay: [8 L]**
   Alpha decay: Velocity and energy of alpha particles, Geiger-Nuttal law, alpha spectra and fine structure, short range and long range alpha particles, disintegration energy, Gamow's theory of alpha decay. (Qualitative treatment)

   Beta Decay: Types of Beta decay, Energies of (Beta -decay, The continuous beta particle spectrum & difficulties in understanding it, Pauli's neutrino hypothesis.

   Gamma Decay : Origin of gamma decay, Internal Conversion, Nuclear isomerism.
   [Patel : 2.3, 4.2.1-4.2.3, 4.3.1- 4.3.3, 4.4.1, 4.4.3, 4.4.4]

5. **Liquid drop model of a nucleus**: **[6 L]**
   Analogy between liquid drop & a nucleus. Wiezsacker's semi empirical mass formula. Mass Parabolas: Prediction of stability against beta decay for members of a isobaric family, Stability against spontaneous fission, Bohr – Wheeler theory for nuclear fission.
   [Patel: 5.3, 5.4, 5.5]

6. **Nuclear Energy: [6 L]**
   Neutron induced fission, Asymmetrical fission, Energy released in the fission of U-235. Fission chain reaction, Principle of a nuclear reactor, Neutron cycle in a thermal nuclear reactor (The four factor formula), Principle of a breeder reactor.
   [Patel: 6.1-6.5, 6.7-6.9]

7. **Nuclear Shell Model**: **[6 L]**
   Experimental evidences that lead to shell model, Main assumption of the single particle shell model, Jensen-Mayer Scheme (No derivation), Predictions of the shell model.
   [Patel: 7.1-7.3, 7.7, 7.8]

8. **Elementary Particle Physics: [8 L]**
   Theory of the electron. Antiparticles. Types and properties of Mesons. Systematics of Elementary Particles. Strangeness Number. Isotopic Spin. Symmetries and Conservation Principles. Theory of Elementary Particles.
   [Beiser: 25.1-25.11]

Experiments:

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length / slope etc
2. Study of nuclear counting statistics
3. Measurement of short half-life
4. Tutorial on Properties of the Nucleus
5. Tutorial on Q value
6. Tutorial on Radioactive decay
7. Tutorial on Liquid drop model
8. Tutorial on Nuclear fission

References:

1. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age Inernational Limited, New Delhi.
2. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

Additional References:

1. Krane, K. 1987, *Introductory Nuclear Physics*, 3rd Edition. Wiley, New Jersey.
2. Kaplan, I. 1956, *Nuclear Physics,* 3rd Edition, Addison-Wesley, Boston.

Paper Title : **Introduction to Special Theory of Relativity**

Paper Code : **PHY-VI.CE-15**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Pre-requisite: Electromagnetic Theory –I (PHY-III.C-5) and Electromagnetic Theory-II (PHY-V.C-7)

Course Objectives: The objective of this course is to introduce students to Special Theory of Relativity.

Learning Outcome: In this course, students will learn the true nature of Non-Relativistic and Relativistic mechanics.

Theory

1. Experimental Background: **[10 L]**

Galilean Transformation, Newtonian relativity, Electromagnetism and Newtonian relativity, Michelson Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Ether Drag hypothesis, Attempts to modify electrodynamics, postulates of the theory of special Relativity. Einstein and origin of relativity theory.
[Ref#1 Article 1.1 to 1.10]

2. Relativistic Kinematics **[9 L]**

Relativity of simultaneity, Derivation of Lorentz transformation equations, some consequences of Lorentz transformation equations, Relativistic addition of velocities, relativistic transformation of velocities and Doppler effect in Relativity .
[Ref#1 Article 2.1to 2.8]

3. Relativistic Mechanics **[8 L]**

Mechanics and Relativity, Redefining momentum, Relativistic momentum, Relativistic mass, Equivalence of mass and energy. The transformation properties of Momentum, Energy, Mass and Force.
[Ref#1 Article 3.1to 3.7]

4. Relativity and Electromagnetism **[10 L]**

Interdependance of electric and magnetic fields, Transformation for E and B, Field of a uniformaly moving point charge, Forces and fields near a current carrying wire, Forces between moving charges,The invariance of Maxwells equations, Limitations of special relativity.

[Ref#1 Article 4.1to 4.8]

5. The Geometric Representation of Space –Time and Twin Paradox [8 L]

Space-Time Diagrams, Simultaneity, Contraction and Dilation, The time Order and Space Separation of events, The route dependance of proper time, space time diagram of the twin paradox, The experimental test.

[Ref#1 Article A1-A3 and B-1 to B-5]

Experiments: (Minimum Six)

1. Michelson Interferometer
2. Tutorial on Relativistic Kinematics
3. Tutorial on Relativistic Kinematics
4. Tutorial on Relativistic Mechanics
5. Tutorial on Relativistic Mechanics
6. Tutorial on Relativity and Electromagnetism
7. Tutorial on Relativity and Electromagnetism

References:

1. Resnick R., 1965, *Introduction to Special Relativity*, John Wiley.

Additional References:

1. Ghatak A., 2009, *Special Theory of Relativity,* Anshan Ltd
2. French A. P., 1968, *Special Relativity*, Chapman & Hall.

Paper Title: Introduction to Materials Science

Paper Code: PHY-VI.CE-16

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Contact Hours: 45 (Theory) + 30 (Practical)

Course Objectives: To acquaint students with fundamentals of materials science and study the properties and applications of materials.

Learning Outcome: At the end of this course, students would be able to investigate the relationship that exists between the structures and properties of materials.

Pre-requisite: Quantum Mechanics (PHY-IV.C-6), Solid State physics (PHY-V.CE-9).

Theory:

1. Structure of Crystalline Solids **[14L]**

Introduction, metallic crystal structures: the face centered cubic crystal structure, the body centered cubic crystal structure, the hexagonal close-packed crystal structure, density computations, atomic arrangements, linear and planar densities, close-packed crystal structures, polymorphism and allotropy, ceramic crystal structures: radius ratio rules, AX-type crystal structures, A_MX_P-type crystal structures, $A_MB_NX_P$-type crystal structures, crystal structures from close packing of anions, ceramic density computations, silicate ceramics, carbon, polymer structures: polymer crystallinity, polymer crystals, x-ray diffraction: determination of crystal structures.

[Callister: 4.1 – 4.20]

2. Imperfections in Solids **[8 L]**

Introduction, point defects: vacancies and self-interstitials, impurities in solids, specification of composition, imperfections in ceramics, miscellaneous imperfections: dislocations-linear defects, interfacial defects, bulk or volume defects, atomic vibrations, defects in polymers, microscopic examination: microscopic techniques, grain size determination.

[Callister: 5.1 – 5.13]

3. Diffusion **[6 L]**

Introduction, diffusion mechanisms, steady-state diffusion, nonsteady-state diffusion, factors that influence diffusion, diffusion in ionic materials, diffusion in polymeric materials.

[Callister: 6.1 – 6.8]

4. Applications and Properties of Ceramics **[9 L]**

Introduction, types and applications of ceramics: glasses, Glass-ceramics, clay products, refractories, abrasives, cements, advanced ceramics, mechanical properties: brittle fracture of ceramics, stress-strain behavior, mechanism of plastic deformations, miscellaneous mechanical considerations, glass properties, heat treatment of glasses, heat treatment of glass ceramics.

[Callister: 12.1 – 12.8, 12.10 – 12.16]

5. Structures of Polymers: **[8 L]**

Introduction, hydrocarbon molecules, polymer molecules, the chemistry of polymer molecules, molecular weight, molecular shape, molecular structure, molecular configurations, thermoplastic and thermosetting polymers, copolymers.

[Callister: 13.1 –13.10]

Experiments: (Minimum Six)

1. Grain size estimation using XRD.
2. Determination of density of materials.
3. Analysis of surface morphology using SEM/TEM
4. Determination of compressibility of liquids using crystal oscillator.
5. To study the corrosion of metals with the help of galvanic cells.
6. Thermal diffusivity of brass.
7. Thermal conductivity of a poor conductor.
8. Specific heat of graphite.

References:

1. Callister W. D., 2015, *Materials Science and Engineering*, John Wiley and Sons, 2nd Ed.

2. West A. R.., 2014, *Solid State Chemistry and its Applications*, John Wiley and Sons.

Additional Reference:

1. Kittel C., 2015, *Introduction to Solid State Physics*, John Wiley and Sons, 8th Edition.

Paper Title : **Introduction to Astronomy and Astrophysics**

Paper Code : **PHY-VI.CE-17**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Course Objectives: The course aims to introduce the students to the Exciting World of Extra-galactic Universe.

Learning Outcome: On completion of this course the students will be able to understand

a) the various Extra-galactic objects.
b) the construction, working and mounting of modern telescopes.
c) Co-ordinate system of Celestial Objects.
d) types of stars and their life cycle.

Theory:

1. Fundamentals of Astronomy: **[9 L]**

Introduction: Components of the Universe; Stars, Planets, Asteroids, Meteors, Comets, Galaxies. Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Kepler's laws, black body radiation and curves, Doppler effect.

[Ref#1: chapter1: 1.1-1.5, chapter 3: 3.1- 3.4]

2. Astronomical Instruments: **[10 L]**

Optical telescopes, mounts, light gathering power, magnification, resolution. Spectroscopes, CCD camera, photometer, filters Radio telescopes, interferometry UV, IR, X-ray and Gamma ray telescopes. Modern telescopes: HST, Chandra.

[Ref#1: chapter19: 19.1-19.5, chapter20: 20.1-20.5]

3. Star and Star Systems **[10 L]**

Stars life cycle, Neutron stars, black holes, white dwarf, Chandrasekhar limit. Spectral classification of stars, O,B,A,F,G,K,M. Sytem of stars: Binaries / Cepheids / RR Lyrae, HR diagram, sun and solar system.

[Ref#1: chapter5: 5.1-5.7, chapter12: 12.3, 12.4]

4. Galaxies, Dark Matter and Dark Energy **[7 L]**

Galaxies, classification of galaxies, Hubble's tuning fork diagram, Open and Globular clusters, ISM.

[Ref#1: chapter16: 16.4, chapter 17: 17.1-17.4]

5. Observational Astronomy **[9 L]**

Co-ordinate system, Celestial hemisphere, Concept of time, Magnitudes: apparent and absolute, constellations. Star dial, Observation of Sun, Eclipses, Moon, planets, meteor showers, transits, occultation's.

[Ref#1: chapter2; 2.1-2., Ref#2; chapter1: 1.1-1.4]

Experiments: (Minimum six)

1. Resolving power of telescope.
2. Study of scattering of light (Diameter of Lycopodium powder).
3. Study of Diffraction using plane grating.
4. To find radius of curvature of a convex lens using optical lever.
5. Measurement of the solar constant.
6. To obtain proper motion of Barnard's star using Aladin.
7. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
8. To determine the elements in sun using Fraunhofer spectra.
9. To estimate Astronomical Unit using Venus transit data by parallax method.
10. Data analysis technique using virtual observatory.
11. Determine the period of revolution of sun using virtual laboratory.

Reference

1. Abhyankar K.D., 2001, *Astrophysics - Stars and Galaxies*, Tata McGraw Hill Pub.
2. Shu F., 1981, *Physical Universe-An Introduction to Astronomy*, University Science Books, U.S.
3. Roy A.E. and Clarke D., 1989, *Astronomy structure of the Universe*, Adam Hilger Pub.
4. Glasstone S., 1965, *Source book on the Space Sciences*, Van Nostrand Reinhold Inc.,U.S
5. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics with Elements of Cosmology*, Narosa Pub.
6. Narlikar J.V., 1976, *Structure of the Universe*, Oxford Paperbacks.
7. Badyanath and Basu., 2010, *An Introduction to Astrophysics*, 2nd Edition, Prentice Hall India Learning Private Limited

<u>Courses for students taking Physics as their Minor subject.</u>

Semester V

1. Statistical Physics and Solid State Physics

Semester VI

1. Atomic and Nuclear Physics

Paper Title : **Statistical Physics and Solid State Physics**

Paper Code : **PHY-V.MI-5**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Contact Hours : **45 (Theory) + 30 (Practical)**

Course Objective: To give the students a firm understanding of the basics of Statistical Physics and Solid State Physics. The course broadly deals with the statistical distribution of particles, structural aspects and electrical properties of crystalline solids, and concept of energy bands in solids.

Learning Outcome: After completion of this course, students will develop a comprehensive broad knowledge in Maxwell-Boltzmann Statistics, Fermi-Dirac Statistics, Bose-Einstein Statistics, Bondings in Solids, Crystal Physics, Electrical properties of solids and Origin of energy band structure in solids.

Theory:

I. Statistical Physics: **[15L]**

Introduction-basic concepts-phase space, microstate, macrostate, thermodynamic Probability, Maxwell-Boltzmann statistics- basic postulates, distribution function, Maxwell Boltzmann energy distribution function for an ideal gas, Applications of Maxwell-Boltzmann Distribution law: Total Internal energy and specific heat at constant volume of an ideal gas, Bose Einstein statistics- postulates, Bose-Einstein distribution law, Fermi-Dirac statistics, Fermi-Dirac distribution law

[Lal, 10.1-10.4, 9.7, 9.8, 11.1-11.4, 12.1,12.2,12.4, 12.5,12.8]

II. Solid State Physics

1. Bonding in Solids: **[3 L]**

Introduction, Bonding in Solids, Ionic bonding, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.

[Palanisamy: 1.1, 1.2, 1.4, 1.6 - 1.9]

2. Crystal Structure: **[9 L]**

Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures, Directions in crystals, Planes in crystals- Miller indices.

[Palanisamy: 2.1, 2.2 - 2.2.3, 2.3 - 2.3.3, 3.1, 3.2, 3.3 -3.3.2]

3. Electron Theory of Metals: **[18 L]**

Introduction, Classical free electron theory, Quantum theory of free electrons, Fermi distribution function, Density of energy states, Sources of electrical resistance, Electrons in a periodic potentials, Energy bands in Solids.

[Palanisamy: 6.1, 6.2 - 6.2.2, 6.3, 6.3.1, 6.4, 6.5, 6.6, 6.7-6.7.5, 6.8]

Experiments: (Minimum Six)

1. Energy band gap of a semiconductor
2. Energy band gap of LEDs
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. Fermi energy of Copper
5. Measurement of Hysteresis loss using CRO
6. Determination of Boltzmann Constant
7. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap

References:

1. Palanisamy P. K., 2004, *Solid State Physics,* Scitech Publications (India) Pvt. Ltd.
2. Pillai S. O., 1999, *Solid State Physics*, 3rd Edition, New Age International (P) Ltd, Publisher.
3. Kittel C., 2004, *Introduction to Solid State Physics*, 8th Edition,John Wiley and Sons.
4. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.
5. Lal B., Subrahmanyam N. And Hemne P. S., 2012, *Heat Thermodynamics and Statis*tical *Physics*, S. Chand & Company Ltd.
6. Beiser, A 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

Paper Title : Atomic and Nuclear Physics

Paper Code : PHY-VI.MI-6

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Contact Hours : 45 (Theory) + 30 (Practical)

Course Objectives: The objective of this course is to introduce students to the fundamental aspects of atomic and nuclear physics.

Learning outcome: After successful completion of this course, student will be able to understand the fundamental principles governing the basic properties of atoms, atomic spectra, nucleus and radioactive decay.

Theory:

1. **Quantum Theory of the Hydrogen Atom**: **[6 L]**
   Schrodinger's equation for the H-atom. Separation of variables, Eigen values, Quantum numbers and Magnetic moment. Angular momentum, Electron Probability density.
   [Beiser 9.1-9.9]

2. **Many Electron Atoms: [7 L]**
   Electron Spin.. Pauli Exclusion Principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions. Electron configuration. Hund's rule. Total angular momentum. L-S coupling. J-J coupling.
   [Beiser 10.1, 10.3- 10.9]

3. **Atoms in a Magnetic Field: [7 L]**
   Effects of magnetic field on an atom. Larmor Precession. The Stern-Gerlach experiment. Spin Orbit Coupling. The Normal Zeeman effect, Lande 'g' factor, Zeeman pattern in a weak field (Anomalous Zeeman effect).
   [Eisberg 8.1-8.4, 10.6]

4. **Atomic Spectra: [4 L]**
   Origin of Spectral lines. Selection rules (derivation from transition probabilities), Alkali metal type spectra, Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra **[Beiser 11.1-11.2, Mcgervey 9.1]**

5. **Properties of the Nucleus: [3 L]**
   Nuclear sizes. Nuclear spin. Binding energy, B.E versus A plot. Saturation of nuclear forces.
   [Beiser: 21.2, 21.4-21.6]

6. **Nuclear Forces and Models:** **[5 L]**
   Main characteristics of Nuclear Forces. Meson theory of Nuclear forces. Yukawa potential. Brief discussion of the Liquid drop Model and Shell Model.
   [Beiser: 22.4-22.6]

7. **Radioactivity and Radioactive Decay:** **[9 L]**
   The law of Radioactivity Decay. Mean lifetime. Half life and Decay constant. Successive radioactive transformation (A-B-C) type, Ideal transient and secular equilibrium. Radioactive series. Carbon dating. Artificial radioactivity. Brief qualitative discussion on apha decay, beta decay and gamma decay.
   [Patel: 2.3, 2.6-2.9, 2.11, 2.13; Beiser: 23.3, 23.6-23.10]

8. **Nuclear Fission and Nuclear Fusion:** **[4 L]**
   Nuclear fission. The chain reaction. Transuranic elements. Thermonuclear energy
   [Beiser: 24.7-24.10]

Experiments: (Minimum Six)

I. Atomic Physics

1. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy.
2. Prism Spectrometer: Optical levelling, Angle of Prism
3. Single Slit Diffraction
4. Diffraction Gratings

II. Nuclear Physics

1. Geiger Muller Counter
2. Tutorial on Properties of the nucleus
3. Tutorial on Nuclear Forces and Models
4. Tutorial on Radioactivity

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.
3. Mcgervey, J. 1983, *Introduction to Modern Physics*, Academic Press, USA.
4. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age Inernational Limited, New Delhi.

Additional References:

1. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
2. Krane, K. 1987, *Introductory Nuclear Physics*, 3rd Edition. Wiley, New Jersey.
3. Kaplan, I. 1956, *Nuclear Physics,* 3rd Edition, Addison-Wesley, Boston.