JSS COLLEGE FOR WOMEN

(AUTONOMOUS)

Saraswathipuram, Mysore-9

BACHELOR OF SCIENCE GRADUATE COURSE

SYLLABUS FOR DSC AND OPEN ELECTIVES

(I to VI Semesters)

UNDER NEP

SUBJECT: PHYSICS

Inclusion of the Syllabus

JSS College for Women (Autonomous), Saraswathipuram, Mysuru-09

PROCEEDINGS

Proceedings of the of the **Board of Studies in Physics** meeting held on 14th August 2023.

The meeting of Board of Studies in Physics was convened at 11A.M. on 14th August 2023 in the Department of Physics, JSS College for Women (Autonomous), Saraswathipuram, Mysuru-09

The following members were Present in the meeting

1. Smt.Sowmya B, Assistant Professor, JSS College for Women (Autonomous), Mysuru.
2. Prof.M S Chandrashekar, Professor, DOS in Physics, Manasagangothri, Mysuru.
3. Dr.H R Sreepad, Associate Professor, Govt. College (Autonomous), Mandya
4. Dr.M V Manjunath, Associate Professor, Maharani's Science College, Mysuru.
5. Dr.S R Kumaraswamy, Associate Professor, Maharani's Science College, Mysuru
6. Dr.Chandra, Assistant Professor, NIE College, Manathavadi Road, Mysuru
7. Sri.Umesh V, Assistant Professor, JSS College for Women (Autonomous), Mysuru.
8. Kum.Divya A, Assistant Professor, MMS & SDM Mahila Vidyalaya, Mysuru.

The following member took leave of Absence

1. Sri.E Manivannan, Project Assistant, Mani Electronics, K.T.Street, Mysuru

With subject to the UG Physics NEP Syllabus of V and VI semesters provided by the University of Mysore, all the members of the Board discussed in length and made a deep analysis on various topics and recommended valuable suggestions to frame the Theory part, Practical part and Activity part for the new **NEP Scheme** Syllabus for V and VI semesters for the Academic year 2023-2024 and onwards.

In the V and VI semester syllabus two new experiments were added to the practical part.

The Board of studies approved the syllabus which includes DSC-5 and DSC-6 major papers of 4 credits (4 hours) each and two practical papers of 2 credits (4hours) each, examination pattern, department regulations, the panel of examiners and question paper pattern.

The Board also approved the Emplotability Skills Syllabus for SEC Paper and Internship (Either External /Internal mode) for VI Semester students for 2 Credits.

This scheme should be effective from the academic year 2023-2024.

The copy of the B.Sc Physics Syllabus of V to VI Semesters under NEP Scheme is annexed herewith.

PREFACE

The syllabus proposed herein for the B.Sc., course in Physics has evolved through detailed discussions with members of Physics faculty in our college as well as many other Physicists and Physics teachers. The changes proposed have constantly kept in mind certain basic approaches in Physics education along with the dynamism resulting from autonomy in education. We are very much aware that Physics forms a major driving force for the present day developments in technology and the consequent socio-economic development of the world at large. The rapid changes in technology and vast variety of the present day technologies put enormous pressure on the practitioners to ensure that their education is extensive as well as intensive. Consequently there is a need for constant upgrading and revision of basic inputs in education at all levels, ensuring a judicial mix of the topics chosen. We have taken the advantage of impetus gained through autonomy, the consequent academic freedom and the possibility of achieving high quality at the institutional level. We are equally aware of the immense responsibility it entails in ensuring a proper match between the products of the education and the professions they might get into restrictions arising primarily from considerations of the available time, manpower and financial resources have also been emphasized during the formulation of the contents. We also believe that there is a vast scope for future improvements and a pressing need for constant up gradation and revision of the contents. We would also urge that the individual teachers feel free to add, delete or modify topics of their choice and provide the relevant feedback to help improve the content formulation.

We thank and gratefully acknowledge the help we have received from all the member of the Physics community and a special thanks to all the members of the board of Studies.

Department Regulations

1. **Teaching instruction per week:**

   For I to VI Semester:

   "Course duration: 16 weeks with 4 hours of instructions per week."

   a) Lecture classes: DSC- 4 Hrs of duration per week (One Paper).

   b) Practical classes: DSC- 4 Hrs of duration per week (One Practical).

2. **Examination:**

   a) Theory:

   C1- Will be assessed for I to VI semester for 20 marks after the completion of first half of the semester by 8th week through Test/Activity/Assignment/Attendance/Seminar/Projects in group and Poster presentation (after the completion of 50% of the syllabus).

   C2- Will be assessed for I to VI semester for 20 marks after the completion second half of the semester by 16th week through Test/Activity/Assignment/Attendance/Seminar/Projects in group and poster presentation (after the completion of rest 50% of the syllabus).

   C3- Examinations for I to VI semester are conducted at the end of every semester for TWO hours of duration. The question paper shall be set for a maximum of 60 marks from I to VI semester.

   b) Practical:

   C1- Will be assessed for I to VI semester for 10 marks after the completion of first half of the semester by 8th week through experiment/continuous assessment of experimental work and record completion/procedure writing/viva/ attendance (after the completion of 50% of the experiments).

   C2- Will be assessed for I to VI semester 15 marks after the completion of second half of the semester by 16th week through experiment/continuous assessment of experimental work and record completion/procedure writing/viva/ attendance (after the completion of all the experiments).

   C3- Examinations for I to VI semester are conducted at the end of every semester for THREE hours of duration for a maximum of 25 marks ONE

experiment shall be conducted in each practical examination.

3. **Eligibility criteria for students :**

   Only the students who have scored minimum of 40% in C1 and C2 put together are eligible to take C3 examination.

4. **Eligibility criteria for teaching faculty:**

   a) **Paper setting**-the teacher with minimum of 5 years of teaching experience in the first grade college are eligible to set the question paper.

   b) **Paper valuation and Practical examination** – the teacher with minimum of 3 years of experience is eligible to become an evaluator and examiner.

5. **Internship**: In VI Semester internship will be guided by the in house teacher for 2 Credits. Students can complete their internship by preparing a dissertation report (either internal work / External work modes) on a project / lecture by an external subject expert/ Field visit/industrial visit/ research lab visit/ Any other relevant mode related to Core Subject based on the need for student's interest.

Course Structure
(Core and Open Electives)

Sem	Course	Paper	Title of the Paper	Instructions per week (Hrs)	Credits	Components Max. Marks			Total Marks	Exam Duration (Hrs)
					L:T:P	C1	C2	C3		
I	DSC-1	Theory	Mechanics and properties of Matter	4	4:0:0	20	20	60	100	02
		Practical	Mechanics and properties of Matter	4	0:0:2	10	15	25	50	03
	OE - 1	Theory	Energy Sources	3	3:0:0	20	20	60	100	02
	OE - 2	Theory	Climate Science	3	3:0:0	20	20	60	100	02
II	DSC-2	Theory	Electricity and Magnetism	4	4:0:0	20	20	60	100	02
		Practical	Electricity and Magnetism	4	0:0:2	10	15	25	50	03
	OE - 3	Theory	Astronomy	3	3:0:0	20	20	60	100	02
	OE - 4	Theory	Medical Physics	3	3:0:0	20	20	60	100	02
III	DSC-3	Theory	Wave Motion and Optics	4	4:0:0	20	20	60	100	02
		Practical	Wave Motion and Optics	4	0:0:2	10	15	25	50	03
	OE - 5	Theory	Optical Instruments	3	3:0:0	20	20	60	100	02
	OE - 6	Theory	Sports Science	3	3:0:0	20	20	60	100	02
IV	DSC-4	Theory	Thermal Physics and Electronics	4	4:0:0	20	20	60	100	02
		Practical	Thermal Physics and Electronics	4	0:0:2	10	15	25	50	03
	OE - 7	Theory	Nanotechnology	3	3:0:0	20	20	60	100	02
	OE - 8	Theory	Electrical Instruments	3	3:0:0	20	20	60	100	02

Sem	Course	Paper	Title of the Paper	Instructions per week (Hrs)	Credits	Components Max. Marks			Total Marks	Exam Duration (Hrs)
					L:T:P	C1	C2	C3		
V	DSC-5	Theory	Classical Mechanics and Quantum Mechanics - I	4	4:0:0	20	20	60	100	02
		Practical	Classical Mechanics and Quantum Mechanics - I	4	0:0:2	10	15	25	50	03
	DSC-6	Theory	Elements of Atomic, Molecular and Laser Physics	4	4:0:0	20	20	60	100	02
		Practical	Elements of Atomic, Molecular and Laser Physics	4	0:0:2	10	15	25	50	03
	SEC	Theory	Employability skills	3	2:0:1	25	----	25	50	01
VI	DSC-7	Theory	Elements of Condensed Matter & Nuclear Physics	4	4:0:0	20	20	60	100	02
		Practical	Elements of Condensed Matter & Nuclear Physics	4	0:0:2	10	15	25	50	03
	DSC-8	Theory	Electronic Instrumentation & Sensors	4	4:0:0	20	20	60	100	02
		Practical	Electronic Instrumentation & Sensors	4	0:0:2	10	15	25	50	03
	INTERNSHIP	Internship	Internship (Internal/External)	2	0:0:2	50	50	-----	100	-----

I Semester (Core)
Mechanics & Properties of Matter

Course Title: Mechanics & Properties of Matter	**Course Credits:** 4
Total Contact Hours: 52	**Duration of ESA:** 2 hours
Formative Assessment Marks: 40	**Summative Assessment Marks:** 60
Model Syllabus Authors:	**Physics Expert Committee**

Mechanics & Properties of Matter		**Hrs**
Credit : 4+2	**Unit – 1** **Theory : 4 hours /Week**	
Chapter No. 1	**Frames of references:** Inertial and non inertial reference frames, A frame moving with uniform velocity with respect to another inertial frame is also inertial, an accelerated frame of reference with respect to an inertial frame is non inertial, Galilean transformation equations, Lorentz transformation equations.	(13)
Chapter No. 2	**Momentum and Energy**: Work and energy, Conservation of momentum (linear). Conservation of energy with examples. Motion of rockets.	
Chapter No. 3	**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.	
Topics for self study(If any)	**Self Study** **Units and measurements:** System of units (CGS and SI), measurement of length, mass and time, dimensions of physical quantities, dimensional formulae. Minimum deviation, errors.	
	Suggested Activities	
Activity No. 1	1. i). Students can measure diameters of small balls of different size and estimate their volumes. 2. ii). Students can measure lengths of nails of different size. iii). Students can measure volume of a liquid iv). Students can measure distances and put the result both in CGS and SI units in 2, 3 and 4 significant figures. Ask them to mention the precession of the measurement. v). students can estimate standard deviations wherever possible.	

Activity No. 2	Students can try and understand conservation of energy in everyday examples. For example: i) What happens in solar conservation panels ii) Pushing an object on the table it moves iii) Moving car hits a parked car causes parked car to move. In these cases, energy is conserved. How? Understand and verifyif possible.	
Unit – 2		
Chapter No. 4.	**Laws of Motion:** Newton's Laws of motion. Dynamics of single and a system of particles. Centre of mass.	(13)
Chapter No. 5.	**Dynamics of Rigid bodies**: Rotational motion about an axis, Relation between torque and angular momentum, Rotational energy. moment of inertia: M I of a rectangular Lamina and solidcylinders. Flywheel, Theory of compound pendulum and determination of g.	
Chapter No. 6.	**Gravitation:** Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved,areal velocity is constant). Kepler's laws (statements). Satellite in a circular orbit.	
Topics for self	**Chapter 7**: Geosynchronous orbits. Basic idea of global	
study(If any)	positioning system (GPS). Ref: 1-4,9,10	
	Suggested Activities	
Activity No. 3	Activity: Moment of inertia is an abstract concept. It simply gives a measure of rotational inertia of a rigid body and it is proportional to the product of the square of radius, r of the body and its mass, m. Students by referring to websites, can construct and perform simple experiments to verify that MI α mr^2.	
	Reference : www.khanacademy.org, www.pinterest.com,www.serc.cerleton.edn	
Activity No. 4	Activity: Prepare suitable charts and give seminar talks in the class.	

Unit - 3		
Chapter No. 7	**Elasticity:** Hooke's law - Stress-strain diagram, elastic moduli-relation between elastic constants, Poisson's Ratio-expression for Poisson's ratio in terms of elastic constants. Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder. Torsional pendulum-Determination of rigidity modulus and moment of inertia - q, η and σ by Searle's method	(13)
	Suggested Activities	

Activity No. 5	**Activity:** Arrange a steel spring with its top fixed with a rigid support on a wall and a meter scale along side. Add 100 g load at a time on thebottom of the hanger in steps. This means that while putting each 100g load, we are increasing the stretching force by 1N. Measure the extension for loads up to 500g. Plot a graph of extension versus load. Shape of the graph should be a straight line indicating that the ratio of load to extension is constant. Go for higher loads and find out elastic limit of the material.	
Activity No.6	**Activity:** Repeat the above experiment with rubber and other materials and find out what happens after exceeding elastic limit. Plot and interpret.	

Unit - 4		
Chapter No. 8	**Surface tension:** Definition of surface tension. Surface energy, relation between surface tension and surface energy, pressure difference across curved surface example, excess pressure inside spherical liquid drop, angle of contact.	(13)
Chapter No.9	**Viscosity:** Streamline flow, turbulent flow, equation of continuity, determination of coefficient of viscosity by Poisulle's method, Stoke's method. Problems.	
Topics for self study(If any)	Capillarity determination of surface tension by drop weight method. Ref: 6,7,9,10	
	Suggested Activities	
Activity No.7	1. Measure surface tension of water and other common liquids and compare and learn i) Why water has high ST? think of reasons. ii) Check whether ST is a function of temperature? You can do it by heating the water to different temperatures and measure ST. iii) Plot ST versus T and learn how it behaves. Mix some quantity of kerosene or any oil to water and measure ST. Check whether ST for the mixture is more or less than pure water. List the reasons.	

Activity No. 8	Activity: 1 Collect a set of different liquids and measure their viscosity.) Find out whether sticky or non-sticky liquids are most viscous. List the reasons. ii) Mix non sticky liquid to the sticky liquid in defined quantities and measure viscosity. Find out viscosity is increasing or decreasing with increase of non-sticky liquid concentration. iii) Do the above experiment by mixing sticky liquid to the non sticky liquid. Find out change in viscosity with increase of concentration of sticky liquid. List the applications where concept of Viscosity plays a dominant role	

Text Books:

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Mechanics by, New Eition	D. S. Mathur	S.Chand & Co.	2000
2	Mechancis and Relativity by 3rd Edition,	Vidwan Singh Soni,	PHI Learning Pvt. Ltd.	
3	Mechanics Berkeley Physics Course, Vol.1:	Charles Kittel, *et.al*.	Tata McGraw-Hill	2007
4	Properties of Matter	Brijlal & Subramanyam.		

References/Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics. 9th Edn,	Resnick, Halliday & Walter,	Wiley	2010
2	Physics Vol-I	Halliday and Resnick,		

List of Experiments to be performed in the Laboratory:

(Minimum EIGHT experiments have to be carried out)

1.	Determination of g using bar pendulum (L versus T and L versus LT^2 graphs).
2.	Determination of moment of inertia of a Fly Wheel.
3.	Determination of rigidity modulus using torsional pendulum.
4.	Modulus of rigidity of a rod – Static torsion method.
5.	Determination of elastic constants of a wire by Searle's method.
6.	Young's modulus by Koenig's method.
7.	Viscosity by Stoke's method.
8.	Verification of Hook's law.
9.	Determination of surface tension of a liquid and the interfacial tension between two liquids using drop weight method.
10.	Study of motion of a spring and to calculate Spring constant, g and unknown mass.
11.	Determination of Young's modulus of a bar by the single cantilever method.
12.	Determination of Young's modulus of a bar by uniform bending method.
13.	Radius of capillary tube by mercury pellet method.
14	Verification of parallel and perpendicular axis theorems.
15	M.I.of an irregular body
16.	Determination of Young's modulus, rigidity modulus and ρ - Searl's double bar

Reference Book for Laboratory Experiments

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics through experiments	B.Saraf	Vikas Publications	2013
2	A lab manual of Physics for undergraduate classes, 1st Edition,		Vikas Publications.	
3	BSc Practical Physics Revised Ed	CL Arora	S.Chand & Co.	2007
4	An advanced course in practical physics.	D. Chatopadhyay, PC Rakshit, B.Saha	New Central Book Agency Pvt Ltd.	2002

Formative Assessment	
Assessment	**Marks**
Internal Assessment	10
Activity	10
REU based Group Activity (Conduction, Report, Presentation)	10
Science Communication (Seminar/Poster/ Mini Project etc)	10
Total	**40**

II Semester (Core)
Electricity & Magnetism

Course Title: Electricity and Magnetism	**Course Credits:** 4
Total Contact Hours: 52	**Duration of ESA:** 2 hours
Formative Assessment Marks: 40	**Summative Assessment Marks:** 60
Model Syllabus Authors:	Physics Expert Committee

Electricity & Magnetism		**Hrs**
Unit – 1		
Chapter No. 1	**Topics to be covered/taught/learnt:** Electric charge and field, Coulomb's law, electric field strength, electric field lines, point charge inan electric field and electric dipole, work done by a charge (derivation ofthe expression for potential energy)	3
Chapter No. 2	**Topics to be Covered** Gauss's law and its applications (electric fields of a (i) spherical charge distribution, (ii) line charge and (iii) an infinite flat sheet of charge).	3
Chapter No. 3	**Topics to be Covered** Electric potential, line integral, gradient of a scalar function, relation between field and potential. Potential due to point charge and distribution of charges (Examples: potential associated with a spherical charge distribution, infinite line charge distribution, infinite plane sheet of charges). Constant potential surfaces, Potential due to a dipole and electric quadrupole.	7
Topics for self study(If any)	*Constant potential surfaces - for self learning* *Work out problems listed in the reference*	
	Suggested Activities	
Activity No. 1	1. Learn the difference between and DC and AC electricity and their characteristics. Voltage and line frequency standards in different countries. 2. A small project report on production of electricity as a source ofenergy: Different methods	
Activity No. 2	1. Learn to use a multimeter (analog and digital) to measure voltage, current and resistance. Continuity testing of a wire. 2. Learn about household electrical connection terminals: Live, neutral and ground and voltage between the terminals. Role of earthing and safety measures	

Unit – 2		
Chapter No. 4.	**Topics to be covered** Conductors in electrostatic field Conductors and insulators, conductors in electric field. Capacitance and capacitors, calculating capacitance in a parallel plate capacitor, parallel plate capacitor with dielectric, dielectrics: an atomic view. Energy storedin a capacitor, Dielectric and Guass's law.	6
Chapter No. 5.	**Topics to be covered** Electric currents and current density. Electrical conductivity and Ohm's law. Physics of electrical conduction, conduction in metals and semiconductors, circuits and circuit elements: Variable currents in capacitor circuits, Resistor, inductor and capacitor and their combination.force on a moving charge.	7
Topics for self study(If any)	*Currents and voltage in combination of R, L and C circuits*	
	Suggested Activities	
Activity No. 3	1. Learn about electrical appliances which work with AC and DC electricity 2. Learn about types of resistors and their colour codes and types ofcapacitors(electrolytic and non-electrolytic)	
Activity No. 4	1. Learn about power transmission: 3-phase electricity, voltage and phase 2. Visit a nearby electrical power station. Interact with line men, Electrical engineers and managers. Discuss about power loss in transmission. How to reduce it? 3. Prepare a small project report on street lighting and types of electrical bulbs.	

Unit – 3		
Chapter No.6	**Topics to be covered** Magnetism: Definition of magnetic field, Ampere's law and Biot-Savart law (magnetic force and magnetic flux), Magnetic force on a current carrying conductor, Hall effect. Electromagnetic induction, conducting rod moving in a magnetic field, law of induction and mutual inductance, self inductance and energy stored in a magnetic field.	7
Chapter No. 7	**Topics to be covered** Alternating current circuits: Resonant circuit, alternating current, quality factor, RL, RC, LC, LCR circuits, admittance and impedance, power and energy in AC circuits.	6
Topics for self study(If any)	Hall Effect	

	Suggested Activities	
ctivity No. 5	**Activity:** 1. Prepare a small project report on street lighting and typesof electrical bulbs. 2. Learn the measurement of electric current using tangentgalvanometer.	
Activity No.6	**Activity:** Build a small coil with insulated copper wire. Connect an ammeter micro/milli ammeter. Verify magnetic induction using a powerful bar magnet.	
Unit - 4		
Chapter No. 8	Electromagnetic waves: Equation of continuity, Maxwell's equations, displacement current, electromagnetic wave, energy transported by electromagnetic waves. Electromagnetic waves in different frames of reference, Field of a current loop, magnetic moment, Electric current in atoms, electron spin and magnetic moment, magnetization and magnetic susceptibility.	8
Chapter No. 9	**Topics to be covered:** Types of magnetic materials: diamagnetic, paramagnetic andferromagnetic materials. B-H hysteresis curves.	5
Topics for self study(If any)	*B-H curves and its characteristics* *Ferrites*	
	Suggested Activities	
Activity No.7	**Activity:** 1. Prepare a small project report on production of magnetic field: Permanent magnets, electromagnets and superconducting magnets. 2. Learn the principle of working of a Gauss meter to measure magnetic field	
Activity No. 8	**Activity:** 1. Model the earth's magnetic field with a diagram. Explain the effect of tilt of the earth's axis and reasons for the change in the tilt of the earth's axis over thousands of years.	

References Books:

SlNo	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics-Part-II,	David Hallidayand Robert Resnick	Wiley Eastern Limited	2001
2	Berkeley Physics Course, Vol-2, Electricity and Magnetism, Special Edition	Edward M Purcell	Tata Mc Graw-Hill Publishing Company, Ltd, New Delhi	2008

List of Experiments to be performed in the Laboratory:

(Minimum EIGHT Experiments to be carried out)

1.	Experiments on tracing of electric and magnetic flux lines for standard configuration.
2.	Determination of components of earth's magnetic field using a Ballistic galvanometer.
3.	Determination of capacitance of a condenser using B.G.
4.	Determination of high resistance by leakage using B.G.
5.	Determination of mutual inductance using BG.
6.	Charging and discharging of a capacitor(energy dissipated during charging and time constant measurements.
7.	Series and parallel resonance circuits (LCR circuits).
8.	Impedance of series RC circuits- determination of frequency of AC.
9.	Study the characteristics of a series RC and RL Circuit.
10.	Determination of self inductance of a coil-Anderson's Bridge
11.	Verification of laws of combination of capacitances and determination of unknown capacitance using de - Sauty bridge.
12.	Determination of B_H using Helmholtz double coil galvanometer and potentiometer.
13	Variation of Xc with frequency and determination of Capacitance.
14.	Measurement of low resistance of a coil using potentiometer

Formative Assessment	
Assessment	**Marks**
Internal Assessment	10
Activity	10
REU based Group Activity (Conduction, Report, Presentation)	10
Science Communication (Seminar/Poster/ Mini Project etc)	10
Total	**40**

III Semester (Core)

Wave Motion and Optics

Program Outcomes:	
1.	Disciplinary knowledge
2.	Communication Skills
3.	Critical thinking, Reflective thinking, Analytical reasoning, Scientific reasoning
4.	Problem-solving
5.	Research-related skills
6.	Cooperation/ Teamwork/ Leadership readiness/Qualities
7.	Information/ Digital literacy/Modern Tool Usage
8.	Environment and Sustainability
9.	Multicultural competence
10.	Multi-Disciplinary
11.	Moral and ethical awareness/Reasoning
12.	Lifelong learning / Self Directed Learning

Course Content Semester – III	
Course Title: Wave Motion and Optics	**Course Credits:** 4
Total Contact Hours: 52	**Duration of ESA:** 2 hours
Formative Assessment Marks: 40	**Summative Assessment Marks:** 60
Model Syllabus Authors: Physics Expert Committee	

Prerequisites	
i.	Fundamentals of waves

Course Learning Outcomes	
At the end of the course students will be able to:	
i.	Identify different types of waves by looking into their characteristics.
ii.	Formulate a wave equation and obtain the expression for different parameters associated with waves.
iii.	Explain and give a mathematical treatment of the superposition of waves under different conditions, such as, when they overlap linearly and perpendicularly with equal or different frequencies and equal or different phases.
iv.	Describe the formation of standing waves and how the energy is transferred along the standing wave in different applications, and mathematically model in the case of stretched string and vibration of a rod.
v.	Give an analytical treatment of resonance in the case of open and closed pipes in general and Helmholtz resonators in particular.
vi.	Describe the different parameters that affect the acoustics in a building, measure it and control it.
vii.	Give the different models of light propagation and phenomenon associated and measure the parameters like the wavelength of light using experiments like Michelson interferometer, interference and thin films.
viii.	Explain diffraction due to different objects like singles slit, two slits, diffraction of grating, oblique incidence, circular aperture and give the theory and experimental setup for the same.
ix.	Explain the polarization of light and obtain how the polarization occurs due to quarter wave plates, half wave plates, and through the optical activity of a medium.

Course Articulation Matrix													
Mapping of Course Outcomes (CO) Program Outcomes													
Course Outcomes / Program Outcomes		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
i.	Identify different types of waves by looking into their characteristics.	X	X	X	X	X	X					X	X
ii.	Formulate a wave equation and obtain the expression for different parameters associated with waves.	X	X	X	X	X	X					X	X
iii.	Explain and give a mathematical treatment of the superposition of waves under different conditions such as when they overlap linearly and perpendicularly	X	X	X	X	X	X					X	X

	with equal or different frequencies and equal or different phases.												
iv.	Describe the formation of standing waves and how the energy is transferred along the standing wave in different applications, and mathematically model in the case of stretched string and vibration of a rod.	X	X	X	X	X	X					X	X
v.	Give an analytical treatment of resonance in the case of open and closedpipes in general and Helmholtz resonators in particular.	X	X	X	X	X	X					X	X
vi.	Describe the different parameters that affect the acoustics in a building, measure it and control it.	X	X	X	X	X	X					X	X
vii.	Give the different models of light propagation and phenomenon associated and measure the parameters like the wavelength of light using experiments like Michelson interferometer, interference and thin films.	X	X	X	X	X	X					X	X
viii.	Explain diffraction due to different objects like singles slit, two slits, diffraction grating, oblique incidence, circular aperture and give the theory and experimental setup for the same.	X	X	X	X	X	X					X	X
ix.	Explain the polarization of light and obtain how the polarization occurs due to quarter wave plates, half wave plates, and through the optical activity of a medium.	X	X	X	X	X	X					X	X

Wave Motion and Optics

Unit – 1 – Waves and Superposition of Harmonic Waves

The Portion to be Covered

Waves: Plane and Spherical Waves. Longitudinal and Transverse Waves. Characteristics of wave motion, Plane Progressive (Travelling) Wave and its equation, Wave Equation – Differential form (derivation). Particle and Wave Velocities: Relation between them, Energy Transport – Expression for intensity of progressive wave, Newton's Formula for Velocity of Sound. Laplace's Correction (Derivation). Brief account of Ripple and Gravity Waves. **(Text Book : 1-4) (5 Hours)**

Superposition of Harmonic Waves : Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats) – Analytical treatment. Superposition of two perpendicular Harmonic Oscillations: Lissajous Figures with equal and unequal frequency- Analytical treatment. Uses of Lissajous' figures. **(Text Book : 1-4) (6 Hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Explain the difference between plane and spherical waves, longitudinal and transverse waves and give their characteristics.	L2	1	1-6, 11-12
ii.	Write down an equation for the progressive wave in its differential form.	L2	1	1-6, 11-12
iii.	Obtain the relation between particle and wave velocity.	L2	1	1-6, 11-12
iv.	Obtain an expression for intensity of progressive waves.	L2	1	1-6, 11-12
v.	Obtain Newton's formula for the velocity of sound and discuss the factors for which sound velocity is dependent.	L2	2	1-6, 11-12
vi.	Apply the Laplace's correction to the equation of motion of a progressive wave.	L2	2	1-6, 11-12
vii.	With examples explain ripple and gravity waves.	L1	2	1-6, 11-12
viii.	Give the theory of superposition of two linear waves having equal frequencies and different frequencies.	L2	3	1-6, 11-12
ix.	Discuss the formation of different Lissajous figures under different conditions of amplitude and frequency when they superimpose perpendicularly.	L2	3	1-6, 11-12
x.	Give some applications of an Lissajous figures.	L1	3	1-6, 11-12
xi.	Higher order problems.	L3	1,2,3	1-6, 11-12

Teaching and Learning Methodology	
Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.	
Assessment Techniques	
One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc	
Suggested Activities (2 Hours)	
Activity No. 1	We know that sound is produced because of vibration. Look into at least 10 musical instruments and identify the regions of vibrations that produces the sound and those parts which enhances the sound because of reverberation. 1. Identify one common element in all of these. 2. Identify equipment which creates beats and try to explain the underlying basic principles. Demonstrate the examples of beats using two tuning forks. 3. Identify what will happen when you drop a stone in a standing water, and when your drop two stones side by side. 4. Make your observations sketch them and comment on it in a report.
Activity No. 2	Draw two sine waves (Amplitude vs time) one shifted with other in phase. Identity where the resonation occurs for each phase shift. Plot phase vs time taken for resonance.
Activity No. 3	Take smooth sand, place a pointed edged pen vertically on the sand. To the mid of the pen, connect two perpendicular threads. Pull these perpendicularthreads by varying the forces and timings. Note down the different shapes produced on the sand. Try to interpret the shapes. Make a report of it
Activity No. 4	Hang a pot with sand, which has a hole in the bottom. Gently pull the pot on one side and observe the pattern formed by the sand on the floor. Report the observations.
Activity No. 5	Design a coupled pendulum. Study the impact of the motion of one pendulum over the other pendulum by varying the length, direction of the motion of one pendulum and mass of pendulum and observe the resultant changes. Trace the path of the bobs and make a report.
Activity No. 6	**Note for the teachers for the activity:** Make 3 groups among students and assign each group the activity of drawing one of the 3 graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation,

	teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Take a stretched spring. Stretch it across two edges. Put a weight on the string, pluck it and measure the amplitude of the vibration. All group will measure the total damping time of oscillating spring. (Using mobile or scale) And plot a graph of the- 1. Varying load on the spring and amplitude at the centre. 2. Take another weight and put that in another place and measure the amplitude of vibration at the centre. 3. Vary the load in the centre of the spring and measure the amplitude at the centre.

Wave Motion and Optics

Unit – 2 – Standing Waves and Acoustics

The Portion to be Covered

Standing Waves : Velocity of transverse waves along a stretched string (derivation), Standing (Stationary) Waves in a String – Fixed and Free Ends (qualitative). Theory of Normal modes of vibration in a stretched string, Energy density and energy transport of a transverse wave along a stretched string. Vibrations in rods – longitudinal and transverse modes (qualitative). Velocity of Longitudinal Waves in gases (derivation). Normal Modes of vibrations in Open and Closed Pipes – Analytical treatment. Concept of Resonance, Theory of Helmholtz resonator. **(Text Book : 1-4) (8 Hours)**
Acoustics: Absorption coefficient, Reverberation and Reverberation time, Sabine's Reverberation formula (derivation), Factors affecting acoustics in buildings, Requisites for good acoustics. Acoustic measurements – intensity and pressure levels. **(Text Book : 1-4) (3 Hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Discuss the Transverse waves produced in stretched string and obtain the expression for the same.	L2	3	1-6, 11-12
ii.	Give a qualitative treatment of vibration of a string when it's both ends are fixed and free.	L2	3	1-6, 11-12

iii.	Explain normal modes of a stretched string. Obtain an expression for the energy density and discuss how this energy is transported along a stretched string.	**L2**	**3**	**1-6, 11-12**
iv.	Quantitatively bring about the mode of vibrations created in a rod.	**L2**	**4**	**1-6, 11-12**
v.	Explain types of waves that are produced in gas. Obtain an expression for the same.	**L2**	**4**	**1-6, 11-12**
vi.	With an analytical treatment explain the concept of resonance using the normal modes of vibrations of open and closed pipes.	**L2**	**5**	**1-6, 11-12**
vii.	Give the theory of Helmholtz resonator and explain how it is used to calculate some parameters of the way the standing waves are set in there.	**L2**	**5**	**1-6, 11-12**
viii.	Define Reverberation, Reverberation time and absorption coefficient of a material.	**L1**	**5**	**1-6, 11-12**
ix.	Obtain Sabine's Reverberation formula and discuss what are the factors on which the Reverberation time depends on?	**L2**	**5**	**1-6, 11-12**
x.	List out which are different parameters within a building which effects the acoustics.	**L1**	**6**	**1-6, 11-12**
xi.	Explain what good acoustics of a building are and how acoustics is measured in terms of intensity and pressure inside a building.	**L2**	**6**	**1-6, 11-12**
xii.	Higher order problems.	**L3**	**4,5,6**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc.

Suggested Activities (2 Hours)	
Activity No. 7	List different phenomenon where standing waves are found in nature. Identify the phenomena and reason for standing waves. Also identify the standing waves in musical instruments. Make a report.
Activity No. 8	**1.** Go to 5 different newly constructed houses when they are not occupied and when they are occupied. Make your observations on sound profile on each room. Give the reasons. Make a report**.** 2. Visit three very good auditoriums, list out different ways in which the acoustic arrangements have been done (as decoration and Civil works). Look for the reasons in Google and identify which is acoustically the best auditorium among the three you visited. Make a report.
Activity No. 9	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Take a bowl of different liquids (water, milk, kerosene, salt water, Potassium Permanganate (KMNO4) solution. Place a small non oily floating material (ex: thin plastic) on the surface of the liquid. Drop a marble on the liquid at the centre of the bowl. Repeat the experiment by dropping the marble from the different heights. Plot a graph of- 1. Height v/s time of oscillation 2. Weight of the marble v/s time of oscillation
Activity No. 10	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study.

	Activity: Take two marble of same weight. Drop both the marbles on the surface of the liquid from some height. With the help of the mobile take the picture and measure the position of interface of two wave fronts formed in the liquid. Plot graphs for different activities by doing the following activities. 1. By dropping two marbles of same weight from different heights. 2. By dropping two marbles of different weight from the same height

Wave Motion and Optics

Unit – 3 – Nature of light and Interference

The Portion to be Covered

Nature of light : The corpuscular model of light-The wave model – Maxwells electromagnetic waves- Wave Particle Duality **(Text Book No 5; Sections 2.1 to 2.4 and 2.8) (2 Hours)**

Interference of light by division of wave front: Huygen's theory-Concept of wave-front-Interference pattern produced on the surface of water-Coherence-Interference of light waves by division of wave-front- Young's double slit experiment- derivation of expression for fringe width-Fresnel Biprism-Interference with white light (Text Book No 5; Sections 12.1 to 12.2, 14.1 to 14.5, 14.7 to 14.9) **(4 Hours)**

Interference of light by division of amplitude: Interference by division of amplitude-Interference by a plane parallel film illuminated by a plane wave-Interference by a film with two non-parallel reflecting surfaces- color of thin films—Newton's rings-(Reflected light)-Michelson Interferometer-Determination of wavelength of light* (Text Book No 5; Sections 15.1 to 15.2, 15.8 to 15.11) **(5 Hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Explain using Michelson interferometer how to determine the wavelength of light.	L2	7	1-6, 11-12
ii.	Give an account of the different possible shapes that are obtained in Michelson interferometer experiment and their relevance.	L2	7	1-6, 11-12
iii.	Discuss the wave model and the Corpuscular model of light.	L2	7	1-6, 11-12
iv.	Explain Maxwells electromagnetic waves.	L2	7	1-6, 11-12
v.	Give an account of the phenomenon of wave-particle duality.	L1	7	1-6, 11-12
vi.	Give the Huygen theory of wave-front.	L1	7	1-6, 11-12

vii.	Define Interference. Give some examples of Interference.	**L1**	**7**	**1-6, 11-12**
viii.	Give the theory of interference due to two coherent sources of light and obtain an expression for the wavelength of monochromatic source of light (Young's double slit experiment)	**L2**	**7**	**1-6, 11-12**
ix.	Explain how using personal biprism, a monochromatic coherent source of light are obtained. Using this experimental setup explain how the wavelength of monochromatic sources of light is determined.	**L2**	**7**	**1-6, 11-12**
x.	Give the theory of interference due to division of amplitude by parallel and non-parallel plates.	**L1**	**7**	**1-6, 11-12**
xi.	Explain how Newton's rings are obtained and discuss how the wavelength of light is determined using this experiment.	**L2**	**7**	**1-6, 11-12**
xii.	Higher order problems.	**L3**	**7**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities (2 Hours)

Activity No. 11

In the table given below explore which phenomenon can be explained by what and Make a report**.**

Sl No	Phenomenon	Particle of Light	Wave Nature	Dual Nature
	Pinhole camera			
1	Formation of images on lenses			
2	Formation of images on mirror			
3	Interference			
4	Polarization			
5	Diffraction due to single slit			
6	Black body radiation			
7	Photoelectric effect			
8	De-Broglie hypothesis			
9	Devison & Germer			

Activity No. 12

Why colour strips are seen in paddles on roads in rainy seasons try to simulate the same. Give the reasons. Make a report**.**

Activity No. 13

Note for the teachers for the activity: Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks.

1. The first slide will explain the process of doing the experiment.

2. In the second slide. Students will show the graph of measurement.

3. In the third slide, they will list three observations from that study.

Activity: Take a bowl of different liquids (water, milk, kerosene, salt water, Potassium Permanganate (KMNO4) solution. Place a small non oily floating material (ex: thin plastic) on the surface of the liquid. Drop two marbles of same weight (mass) from the same height on to the surface of the water but at the different time intervals. Plot graph for the different observations.

For teachers: Demonstrate the formation of Lissajous Figure using a CRO. Give different shapes of Lissajous Figure with varying frequency and amplitude. Ask the students to comment on the observations.

Wave Motion and Optics

Unit – 4 – Diffraction and Polarisation

The Portion to be Covered

Fraunhofer diffraction : Introduction- Fraunhofer diffraction- Single slit diffraction pattern-position of Maxima and Minima (Qualitative arguments)- Two slit diffraction pattern-position of Maxima and minima- Theory of plane diffraction Grating-Grating spectrum- normal and oblique incidence-Resolving power and dispersive power of a grating Single slit; Double Slit. Multiple slits & Diffraction grating. (Text Book No 5; Sections 18.1 to 18.2, 18.6,18.8 to 18.9) **(4 Hours)**

Fresnel Diffraction- Fresnel half period zones-Diffraction by a circular aperture-diffraction by an opaque disc-The zone plate –comparison between zone plate and convex lens. (Text Book No 5; Sections 20.1 to 20.3) **(3 Hours)**

Polarisation: Introduction-Production of polarized light- The wire Grid polarizer and Polaroid-Superposition of two disturbances-Phenomenon of double refraction-Quarter wave plates and half wave plates- Analysis of polarized light-optical activity**.** (Text Book No 5; Sections 22.1, 22.3,22.4,22.6 to 22.8**) (4 Hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Define Fraunhofer diffraction.	**L2**	**8**	**1-6, 11-12**
ii.	Give a qualitative treatment of single slit/diffraction double slit diffraction.	**L2**	**8**	**1-6, 11-12**
iii.	Explain the theory of diffraction due to grating and the normal and oblique incidence.	**L2**	**8**	**1-6, 11-12**
iv.	Explain how the resolving power of a grating depends of the number of slits used.	**L2**	**8**	**1-6, 11-12**
v.	Give the theory of Fersnel half period zones.	**L2**	**8**	**1-6, 11-12**
vi.	Discuss zone plates with respect to convex lenses.	**L2**	**8**	**1-6, 11-12**
vii.	Explain optical polarization and polaroids.	**L2**	**9**	**1-6, 11-12**
viii.	Give different types of polaroids.	**L2**	**9**	**1-6, 11-12**
ix.	Give the theory of phenomenon of double refraction and explain what are ordinary and extraordinary rays.	**L2**	**9**	**1-6, 11-12**
x.	Give the theory of quarter wave plates and half wave plates.	**L2**	**9**	**1-6, 11-12**
xi.	Explain optical activity with theory. Give an experimental method to measure the optical activity of a material.	**L2**	**9**	**1-6, 11-12**
xii.	Higher order problems.	**L3**	**8,9**	**1-6, 11-12**

Teaching and Learning Methodology	
Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.	
Assessment Techniques	
One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc	
Suggested Activities (2 Hours)	
Activity No. 14	Explain polarization of light through a chart. List out the surfaces that reflect polarized light. Learn how polarization of light can be done by both transmission and reflection. Perform an experiment and make a report. USING CDs AND DVDs AS DIFFRACTION Gratings Ref:https://www.nnin.org/sites/default/files/files/Karen_Rama_USING_CDs_AND_DVDs_AS_DIFFRACTION_GRATINGS_0.pdf Obtain the diffraction spectra using a CD and design an experiment to find the distance between the tracks on it) (Ref: https://www.brighthubeducation.com/science-lessons-grades-9-12/39347-diffraction-experiment-measuring-groove-spacing-on-cds/, https://silo.tips/download/diffraction-from-a-compact-disk)
Activity No. 15	What is the physics behind making 3D movies? Group Discussion (https://www.slideserve.com/rae/physics-behind-3d-movies-powerpoint-ppt-presentation) Make a report.
Activity No. 16	List out different types of zone plates and look for their applications in day to day life. Make a report.
Activity No. 17	Collect information and study how optically polarizing lenses are made. Visit a nearby lens making facility. Learn the principle behind sunglasses. Make a report.
Activity No. 18	**Note for the teachers for the activity:** Make 3 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment.

	2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Identify any 3 sharp edges of varying thickness and assign them to 3 groups. Shine a laser light pointing towards the edge of the needle. Observe the patterns formed on the wall or screen and measure the distance between the bands. Correlate the distance between the bands formed with the thickness of the edge and the distance from the edge to the screen. By this, calculate the wavelength of the laser light used.

Textbooks

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1.	The Physics of Waves and Oscillations,	N K Bajaj	Tata McGraw-Hill Publishing Company Ltd., Second Edition,	1984
2.	Waves and Oscillations	N Subramanyam and Brij Lal	Vikas Publishing House Pvt. Ltd., Second Revised Edition	2010
3.	A Text Book of Sound	D R Khanna and R S Bedi	Atma Ram & Sons, Third Edition	1952
4.	Oscillations and Waves	Satya Prakash	Pragathi Prakashan, Meerut, Second Edition	2003
5.	Optics	Ajoy Ghatak	McGraw Hill Education (India) Pvt Ltd	2017
6.	A text Book of Optics	Brij Lal, M N Avadhanulu & N Subrahmanyam	S. Chand Publishing	2012

References Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1.	Berkeley Physics Course – Waves,	Frank S Crawford Jr.	Tata Mc Graw-Hill Publishing Company Ltd., Special Indian Edition,.	2011
2.	Optics	Eugene *Hecht*	Pearson Paperback	2019

3.	Introduction To Optics	Pedrotti and Frank L ,	Pearson India	3rd Edition
4.	Fundamentals of Optics	Francis Jenkins Harvey White	McGraw Hill Education	2017

Formative Assessment	
Assessment	**Marks**
Internal Assessment	10
Activity	10
REU based Group Activity (Conduct, Report, Presentation)	10
Science Communication Seminar/Poster etc.)	10
Total	**40**

List of Experiments to be performed in the Laboratory (Minimum EIGHT Experiments have to be carried out)	
1.	Velocity of sound through a wire using Sonometer.
2.	Frequency of AC using Sonometer.
3.	Study of Lissajous' Figures
4.	To verify the laws of transverse vibration using Melde's apparatus.
5.	Helmholtz resonator using tuning fork.
6.	Helmholtz resonator using electrical signal generator.
7.	To determine refractive index of the Material of a prism (Calcite) using sodium source.
8.	To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
9.	To determine the wavelength of sodium source using Michelson's interferometer.
10.	To determine wavelength of sodium light using Fresnel Biprism.
11.	To determine wavelength of sodium light using Newton's Rings
12.	To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
13.	To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
14.	To determine dispersive power and resolving power of a plane diffraction grating.
15.	To determine Specific rotation of a given solution – Using Polarimeter

Reference Book for Laboratory Experiments				
Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1.	Advanced Practical Physics for students	B.L. Flint and H.T. Worsnop	Asia Publishing House.	1971
2.	A Text Book of Practical Physics	**1.** Prakash & Ramakrishna	Kitab Mahal, 11th Edition	2011
3.	Advanced level Physics Practicals	Michael Nelson and Jon M. Ogborn	Heinemann Educational Publishers, 4th Edition	1985
4.	A Laboratory Manual of Physics for undergraduate classes	D.P.Khandelwal	Vani Publications.	1985

IV Semester (Core)

Thermal Physics and Electronics

Program Outcomes:	
1.	Disciplinary knowledge
2.	Communication Skills
3.	Critical thinking, Reflective thinking, Analytical reasoning, Scientific reasoning
4.	Problem-solving
5.	Research-related skills
6.	Cooperation/ Teamwork/ Leadership readiness/Qualities
7.	Information/ Digital literacy/Modern Tool Usage
8.	Environment and Sustainability
9.	Multicultural competence
10.	Multi-Disciplinary
11.	Moral and ethical awareness/Reasoning
12.	Lifelong learning / Self Directed Learning

Course Content Semester – IV	
Course Title: Thermal Physics and Electronics	**Course Credits:** 4
Total Contact Hours: 52	**Duration of ESA:** 2 hours
Formative Assessment Marks: 40	**Summative Assessment Marks:** 60
Model Syllabus Authors: Physics Expert Committee	

Prerequisites	
i.	Study of Pre-University

Course Learning Outcomes	
At the end of the course students will be able to:	
i.	Apply the laws of thermodynamics and analyze the thermal system.
ii.	Apply the laws of kinetic theory and radiation laws to the ideal and practical thermodynamics systems through derived thermodynamic relations.
iii.	Use the concepts of semiconductors to describe different Semiconductor devices such as diode transistors, BJT, FET etc and explain their functioning.
iv.	Explain the functioning of OP-AMPS and use them as the building blocks of logic gates.
v.	Give the use of logic gates using different theorems of Boolean Algebra followed by logic circuits.

Course Articulation Matrix													
Mapping of Course Outcomes (CO) Program Outcomes													
Course Outcomes / Program Outcomes		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
i.	Apply the laws of thermodynamics and analyze the thermal system.	X	X	X	X	X	X					X	X
ii.	Apply the laws of kinetic theory and radiation laws to the ideal and practical thermodynamics systems through derived thermodynamic relations.	X	X	X	X	X	X					X	X
iii.	Use the concepts of semiconductors to describe different Semiconductor devices like diode transistors, BJT, FET etc and explain their functioning.	X	X	X	X	X	X					X	X
iv.	Explain the functioning of OP-AMPS and them as the building blocks of logic gates.	X	X	X	X	X	X					X	X
v.	Give the use of logic gates using different theorems of Boolean Algebra followed by logic circuits.	X	X	X	X	X	X					X	X

Thermal Physics and Electronics

Unit – 1

The Portion to be Covered

Laws of Thermodynamics:

Review of the concepts of Heat and Temperature. **(1 Hour)**

First Law of Thermodynamics: Differential form, Internal Energy. Equation of state for an adiabatic process, Work Done during Isothermal and Adiabatic Processes. **(3 Hours)**

Second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Reversible and Irreversible processes with examples. Heat Engines: Carnot engine & efficiency (no derivation). Refrigeration & coefficient of performance, Applications of Carnot engine in locomotion, Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Concept of Entropy, Second Law of Thermodynamics in terms of Entropy **(5 Hours)**

Third Law of Thermodynamics: Statement, Significance and Unattainability of Absolute Zero. **(2 Hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Explain the first law of thermodynamics.	L1	1	1-6,11-12
ii.	Give the differential form of the first law of thermodynamics and define what the internal energy is.	L2	1	1-6,11-12
iii.	Obtain an expression for work done in isothermal and adiabatic processes.	L2	1	1-6,11-12
iv.	Give two systems of units of temperature measurement and give their equivalence.	L2	1	1-6,11-12
v.	Describe and Discuss heat engine based on Carnot cycle.	L2	1	1-6,11-12
vi.	Explain how the efficiency of refrigeration is measured?	L2	1	1-6,11-12
vii.	Detail out the application of the Carnot engine to a locomotion system.	L1	1	1-6,11-12
viii.	Define entropy and write an expression for entropy using the second law of thermodynamics.	L2	1	1-6,11-12
ix.	State the third law of thermodynamics and give its significance using the third law of thermodynamics describing why absolute zero temperature is not unattainable.	L2	1	1-6,11-12
x.	High Order Problems.	L3	1	1-6,11-12

Teaching and Learning Methodology	
Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.	
Assessment Techniques	
One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc	
Suggested Activities (2 Hours)	
Activity No. 1	I feel cold because coldness enter my body. Discuss the statement in day-to-day life. Approximately give examples of **(i)** open system **(ii)** closed system and **(iii)** isolated system Discuss when the temperature of the body is locked until what time you hold the thermometer in contact with a body. Discuss it in contact with laws of thermodynamics. Discuss why when a person works or does exercise, he sweats. Reason it with the laws of thermodynamics.
Activity No. 2	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study. **Activity:** Take four different sizes of same metal, preferable of same shape and give one piece to each group. Heat it uniformly on a hot plate. Keep a beaker of water with a thermometer immersed in it. Drop one hot metal into the water and record the temperature with time. Repeat the experiment for the other heated metal pieces of different sizes. **(i)** Plot a graph for the volume of the metal piece used v/s respective temperature change observed. **(ii)** Determine the heat capacity and specific heat of the metal used.

	All groups shall also do the following activity:
Activity No. 3	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study. **Activity:** Take ice cubes of different size and immerse in water and measure the temperature change with time and repeat the experiment. Graph the observations.

Thermal Physics and Electronics

Unit – 2

The Portion to be Covered

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. And their relation. **(1 Hour)**

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations (1) First order Phase Transitions with examples, Clausius - Clapeyron Equation (2) Values of Cp-Cv (3) Joule-Thomson Effect and Joule-Thomson coefficient and Derive an equation for Vander Walls gas. Attainment of low temperature by liquefaction of gases and adiabatic demagnetization. **(3 Hours)**

Kinetic Theory of Gases: Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas: Mean, RMS and Most Probable Speeds. Degrees of Freedom, Law of Equipartition of Energy. Specific heats of Gases. **(2 Hours)**

Radiation: Blackbody radiation, spectral distribution, the concept of energy density and pressure of radiation, Wien's law, Wien's displacement law, Stefan-Boltzmann law, Rayleigh-Jeans law, Planck's law of radiation, derivation of Planck's law of radiation using Einstein's A and B coefficients, derivation of Rayleigh-Jeans law, Wein's displacement law and Stefan's law from Planck's law of radiation, Ultraviolet Radiation catastrophe and. **(4 Hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	State Maxwell relations.	**L1**	**2**	**1-6, 11-12**
ii.	Give examples where Maxwells relations are used.	**L1**	**2**	**1-6, 11-12**

iii.	Explain the phase transition. Which is called as first order phase transition? Give Examples	**L2**	**2**	**1-6, 11-12**
iv.	State Clausius - Clapeyron Equation.	**L1**	**2**	**1-6, 11-12**
v.	Obtain an equation for difference in C_P - C_V.	**L2**	**2**	**1-6, 11-12**
vi.	State Joule-Thomson effect and Joule-Thomson coefficient.	**L1**	**2**	**1-6, 11-12**
vii.	Obtain an expression, giving the relation between pressure, volume and temperature for a real gas (Vander Waals gas).	**L2**	**2**	**1-6, 11-12**
viii.	Explain adiabatic demagnetization and how it is used to obtain low temperature by the liquidation of gases?	**L2**	**2**	**1-6, 11-12**
ix.	State Maxwell-Boltzmann Law of Distribution of Velocities in Ideal gases.	**L1**	**2**	**1-6, 11-12**
x.	Explain the mean RMS and most probable speeds in ideal gases.	**L1**	**2**	**1-6, 11-12**
xi.	Explain degrees of freedom associated with particles in an ideal gas?	**L2**	**2**	**1-6, 11-12**
xii.	Define the specific heat of a gas.	**L1**	**2**	**1-6, 11-12**
xiii.	Explain black body radiation and its spectral distribution.	**L1**	**2**	**1-6, 11-12**
xiv.	Explain the different laws used to describe different parts of the curves of a spectral distribution of black body radiation.	**L2**	**2**	**1-6, 11-12**
xv.	Define ultraviolet radiation catastrophe? Discuss its importance in the explanation of black body radiation.	**L2**	**2**	**1-6, 11-12**
xvi.	Define Planck's law of radiation and discuss how it could describe the whole black body radiation curve.	**L2**	**2**	**1-6, 11-12**
xvii.	High Order Problems.	**L3**	**2**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities (2 Hours)	
Activity No. 4	**(i)** Measuring the Solar Constant Materials: Simple flat sided Jar and Thermometer. Activity: Bottle containing water is exposed to solar radiation. The rise in temperature and time taken are noted. Calculate the heat absorbed by water and relate it to the output of the Sun. **(ii)** Thermo emf Materials: Suitable two dissimilar metal wires, voltage measuring device. Activity: In this experiment student will assemble the thermocouple and study the three effects namely, Seebeck, Peltier, and Thompson. **(iii)** Inverse square law of radiation Materials: A cardboard with a grid, cardboard with a hole, supporting clips, a ruler, candle. **(iv)** Activity: Students set the device. They count the lighted squares on the cardboard with the grid by varying the distance. And make necessary measurements and calculations to arrive at the inverse square law of radiation. Ref: Activity Based Physics Thinking Problems in Thermodynamics: Kinetic Theory http://www.physics.umd.edu/perg/abp/think/thermo/kt.htm
Activity No. 5	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study. **Activity:** Take two dissimilar metal wires. Spot weld them forming two junctions. Dip one junction in ice and heat the other junction with a burner. Plot a graph of time of heating v/s Thermo EFM generated in the voltmeter.
Activity No. 6	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study.

	Activity: Make 4 groups and give different-sized balloons to each group. Fit different-sized nozzles into the mouth of the large balloons. Measure the temperature or the EMF generated using a thermocouple placed at the mouth of the nozzle as the pressurised gas is released. Plot a graph of time v/s temperature. Vary the volume of the balloon and repeat the experiment. Plot the graph of volume v/s temperature difference created.

Thermal Physics and Electronics

Unit – 3

The Portion to be Covered

Semiconductor devices: Review of Intrinsic and Extrinsic semiconductors, p-n junction and its Characteristics and Parameters, Diode approximations, Half-wave rectifier, Full-wave rectifier, Zener diode voltage regulators: Regulator circuit with no load, Loaded Regulator. **(5 hours)**

Junction Transistors: Basics of Bipolar Junction Transistors (BJT), BJT operation, Common Base, Common Emitter and Common Collector Characteristics. Field Effect Transistor (FET) and its characteristics. Transistor as an Amplifier- CE Amplifier and Oscillator – Phase Shift Oscillator, Wiens Bridge oscillator. **(6 hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Define Semiconductors and Band Gap. Explain on what basis they are classified as intrinsic and extrinsic.	**L2**	**3**	**1-6, 11-12**
ii.	Define PN junction. Explain it's functioning in forward and reverse bias.	**L1**	**3**	**1-6, 11-12**
iii.	Explain the approximation used in a real diode with respect to an ideal PN Junction?	**L2**	**3**	**1-6, 11-12**
iv.	With a schematic diagram, explain half wave and full wave rectifiers.	**L1**	**3**	**1-6, 11-12**
v.	Define a Zener diode and explain how it is different from an ordinary diode using V-I curves?	**L2**	**3**	**1-6, 11-12**
vi.	With the schematic diagram, explain the working of voltage regulators of different types using a Zener diode.	**L1**	**3**	**1-6, 11-12**
vii.	Give the basic concepts used in the instruction of bipolar junction transistor and its operation.	**L1**	**3**	**1-6, 11-12**

viii.	Compare the V-I curve of common base common emitter and common collector BJT curves while explaining their working principles.	**L2**	**3**	**1-6, 11-12**
ix.	Define FET? Give its characteristics.	**L1**	**3**	**1-6, 11-12**
x.	Explain how a transistor can be used as an amplifier and an oscillator using a circuit diagram.	**L2**	**3**	**1-6, 11-12**
xi.	High Order Problems.	**L3**	**3**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities (2 Hours)

Activity No. 7	Wire a regulated DC power supply on a bread board or groove board to give a regulated output voltage of + 5 V; +15 V; Dual power output : ± 5 V; Dual power output : ± 15 V. Use: 3-pin voltage regulators. Components required: 1.Step down transformer- 1 No. (5 V tapping, 100 – 500 mA current rating), BY 127 semiconductor diodes – 4 Nos, Inductor -1, Capacitor - 1, 3 pin 5V regulator-1 Search for circuit diagram in books/net. **Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study.

	Activity: Form 3 groups and tell them to make a DC supply of low current of different voltages like 5V, 10V, and 15V on a breadboard
Activity No. 8	**(i)** Learn to identify the terminals of different types (packages) of BJTs. **(ii)** In the case of power transistors, learn how to fix a heat sink for the transistor. **(iii)** Learn the difference between BJT and FET in its operational characteristics.
Activity No. 9	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. **(i)** The first slide will explain the process of doing the experiment. **(ii)** In the second slide. Students will show the graph of measurement. **(iii)** In the third slide, they will list three observations from that study. **Activity:** Take any 3 diode and assign one to each group. Measure its resistance when dipped in ice and heating the ice till it boils. Using this data, plot calibration curve of temperature v/s resistance and also the cooling curve of temperature V/s time for the diode by each group.

Thermal Physics and Electronics

Unit – 4

The Portion to be Covered

Electronics: Integrated Circuits (Analog and Digital), Operational Amplifier, Ideal characteristics of Op-Amp, Inverting and Non-Inverting Configurations. Applications- Voltage Follower, Addition and Subtraction. **(4 hours)**

Digital: Switching and Logic Levels, Digital Waveform. Number Systems: Decimal Number System, Binary Number System, Converting Decimal to Binary, Hexadecimal Number System: Converting Binary to Hexadecimal, Hexadecimal to Binary. **(3 hours)**

Boolean Algebra Theorems: De Morgan's theorem. Digital Circuits: Logic gates, NOT Gate, AND Gate, OR Gate, NAND Gate, NOR Gate, Algebraic Simplification, Implementation of NAND and NOR functions. **(4 hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO

i.	Define op-amps and give the characteristics of an ideal op-amp.	**L1**	**4**	**1-6, 11-12**
ii.	Explains an inverting and non-inverting configuration of typical op-amps, with a schematic diagram.	**L2**	**4**	**1-6, 11-12**
iii.	Explain how op-amps can be used as a voltage follower, with a schematic diagram and with relevant expressions.	**L2**	**4**	**1-6, 11-12**
iv.	Explain how op-amps can be used as a voltage follower, adder and subtractor, with a schematic diagram and with relevant expressions.	**L2**	**4**	**1-6, 11-12**
v.	Give different digital wave forms and explain how one can visualize the switching and logic levels.	**L1**	**5**	**1-6, 11-12**
vi.	Write any four-digit numbers other than zero in the decimal number system and convert that into binary and hexadecimal.	**L2**	**5**	**1-6, 11-12**
vii.	Write any number in a Binary System of 8 digits other than zero and convert it into decimal and hexadecimal.	**L2**	**5**	**1-6, 11-12**
viii.	Write any number in the hexadecimal system of 4 digits other than zero and converted it into a binary and decimal number.	**L2**	**5**	**1-6, 11-12**
ix.	Give simplified diagram for a given Boolean circuit diagram of logic gates, and verify using the De-Morgans theorem.	**L2**	**5**	**1-6, 11-12**
x.	Why are X-NOR gates called Universal Gates?	**L2**	**5**	**1-6, 11-12**
xi.	High Order Problems.	**L3**	**4, 5**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities (2 Hours)

Activity No. 10	Learn how to implement logic functions (AND, OR, NOT) using just diodes and resistors.

	With a circuit diagram show how different types of gates can be built by X-NOR gates.
Activity No. 11	**Operational Amplifiers** **(i)** Understand the concept of virtual ground of an OP-AMP. **(ii)** Learn the different types of op-amps used for different applications. **(iii)** What is a buffer? Prepare a report on buffers and its application in instrumentation electronics.
Activity No. 12	**(i)** A man has to take a wolf, a goat, and some cabbage across a river. His rowboat has enough room for the man plus either the wolf or the goat or the cabbage. If he takes the cabbage with him, the wolf will eat the goat. If he takes the wolf, the goat will eat the cabbage. Only when the man is present are the goat and the cabbage safe from their enemies. All the same, the man carries wolf, goat, and cabbage across the river. How? Write the truth table for the above story and implement using gates. **(ii)** A locker has been rented in the bank. Express the process of opening the locker in terms of digital operation. **(iii)** A bulb in a staircase has two switches, one switch being at the ground floor and the other one at the first floor. The bulb can be turned ON and also can be turned OFF by and one of the switches irrespective of the state of the other switch. The logic of switching of the bulb resembles.

Textbooks

Sl No	Title of the Book
1.	Electronic Devices and Circuits, David A. Bell, 2004, PHI, New Delhi
2.	Integrated Electronics, Jacob Millman and CC Halkias
3.	Digital Fundamentals, Floyd, 2001, PHI, New Delhi

References Books

Sl No	Title of the Book
1.	Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2.	Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
3.	A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
4.	Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5.	Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6.	An Introduction to Thermal Physics, Daniel V Schroeder, 2020, Oxford University Press

Formative Assessment	
Assessment	**Marks**
Internal Assessment	10
Activity	10
REU based Group Activity (Conduction, Report, Presentation)	10
Science Communication (Seminar/Poster/ Mini Project etc)	10
Total	**40**

List of Experiments to be performed in the Laboratory (Minimum EIGHT Experiments have to be carried out)	
1.	Mechanical Equivalent of Heat by Callender and Barne's method
2.	Coefficient of thermal conductivity of Copper by Searle's apparatus
3.	Coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method
4.	Determination of Stefan's constant/ Verification of Stefan's law
5.	Determination of Specific heat of a given liquid – Newton's law of cooling
6.	Variation of thermo-emf across two junctions of a thermocouple with temperature
7.	Verification of Clausius –Clapeyron equation and determination of specific enthalpy
8.	V-I Characteristics of Silicon & Germanium PN Junction diodes (FB & RB) V-I Characteristics of Zener Diode and voltage regulator
9.	Characteristics of BJT in Common Emitter Configuration Frequency response of CE Amplifier Frequency response of CC Amplifier (Emitter Follower).
10.	Half Wave and Full Wave Rectifier Without Filter Half Wave and Full Wave Rectifier with Filter
11.	Applications of Operational Amplifier Non-inverting and Inverting op-amp circuits Voltage follower, Adder and Subtractor circuits
12.	Truth table verification of logic gates using TTL 74 series ICs(7400 & 7402). Transfer characteristics of a TTL gate using CRO. Logic Gates; Combinational Circuits; Sequential Circuits
13.	V-I Characteristics FET
14.	Determination of frequency of Phase shift Oscillator
15	Determination of frequency of Wien Bridge Oscillator

Reference Book for Laboratory Experiments	
Sl No	**Title of the Book**
1.	Basic Electronics Lab (P242) Manual 2015-16, National Institute of Science Education and Research, Bhubaneswar, 2015.
2.	**Suggested Readings:** 1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e. 2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e.

Open Electives for I Semester

OE-1: ENERGY SOURCES

Duration: 3 hrs /week **Max Marks: 60**

		No. of lectures
Unit-I	**Non-Renewable energy sources**	
	Chapter-1: Introduction	
	Energy concept-sources in general, its significance & necessity. Classification of energy sources: Primary and Secondary energy, Commercialand Non-commercial energy, Renewable and Non-renewable energy,Conventional and Non-conventional energy, Based on Origin-Examples and limitations. Importance of Non-commercial energy resources.	**04**
	Chapter-2: Conventional energy sources	
	Fossil fuels & Nuclear energy- production & extraction, usage rate and limitations. Impact on environment and their issues& challenges. Overview of Indian & world energy scenario with latest statistics-consumption & necessity. Need of eco-friendly & green energy & their related technology.	**09**
	Total	**13**
Unit-II	**Renewable energy sources**	
	Chapter-1: Introduction:	
	Need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.	**05**
	Chapter 2 : Solar energy:	
	Solar Energy-Key features, its importance, Merits & demerits of solar energy, Applications of solar energy. Solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell -brief discussion of each. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	**08**
	Total	**13**
Unit-III	**Chapter-3: Wind and Tidal Energy harvesting**:	
	Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy.	**07**

	Chapter-4 : Geothermal and hydro energy	
	Geothermal Resources, Geothermal Technologies.	**02**
	Hydropower resources, hydropower technologies, environmental impact of hydro power sources.	**03**
	Carbon captured technologies, cell, batteries, power consumption	**01**
	Total	**13**
	Reference Books: 1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi 2. Solar energy - M P Agarwal - S Chand and Co. Ltd. 3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd. 4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University. 5. Dr. P Jayakumar, Solar Energy: Resource Assessment Handbook, 2009 6. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA). 7. http://en.wikipedia.org/wiki/Renewable_energy	

OE-2: Climate Science

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Duration: 3 hrs /week **Max Marks: 60**

Chapter 1:	**Atmosphere** Atmospheric Science (Meteorology) as a multidisciplinary science. Physical and dynamic meteorology, Some terminology, difference between weather and climate, weather and climate variables, composition of the present atmosphere: fixed and variable gases, volume mixing ratio (VMR), sources and sinks of gases in the atmosphere. Green house gases. Structure (layers) of the atmosphere.Temperature variation in the atmosphere, temperature lapse rate,mass, pressure and density variation in the atmosphere. Distribution of winds.	(13 hours)
Chapter 2:	**Climate Science** Overview of meteorological observations, measurement of: temperature, humidity, wind speed and direction and pressure. Surface weather stations, upper air observational network, satellite observation. Overview of clouds and precipitation, aerosol size and concentration, nucleation, droplet growth and condensation (qualitative description). Cloud seeding, lightning and discharge. Formation of trade winds, cyclones. Modelling of the atmosphere: General principles, Overview of General Circulation Models (GCM) for weather forecasting and prediction. Limitations of the models. R and D institutions in India and abroad dedicated to climate Science, NARL, IITM, CSIR Centre for Mathematical Modeling and Computer Simulation, and many more	(13 hours)
Chapter 3:	**Global Climate Change** Green house effect and global warming, Enhancement in concentration of carbon dioxide and other green house gases in the atmosphere, Conventional and non-conventional energy sources and their usage. EL Nino/LA Nino Southern oscillations. Causes for global warming: Deforestation, fossil fuel burning, industrialization. Manifestations of global warming: Sea level rise, melting of glaciers, variation in monsoon patterns, increase in frequency and intensity of cyclones, hurricanes, tornadoes. Geo-engineering as a tool to mitigate global warming? Schemes of Geo-engineering.	(13 hours)
	References: 1. Basics of Atmospheric Science – A Chndrashekar, PHI Learning Private Ltd. New Delhi, 2010. 2. Fundamentals of Atmospheric Modelling- Mark Z Jacbson, Cambridge University Press, 2000.	

Open Electives for II Semester

OE-3: Astronomy

Duration: 3 hrs /week **Max Marks: 60**

Content		Hrs
Unit – 1 -History and Introduction		
Chapter 1	Ancient Astronomy Greek Observations, Sumerian Observations, Mayan Observations, Arabic Observations ,Chinese Observations	2
Chapter 2	Indian Astronomy Vedic Astronomy, Ancient Astronomy – Aryabhata, Varahamihira, Bhaskara, Astronomy in Indian Scriptures, Precession of the Equinox, Celebrations of Equinox	2
Chapter 3	Medieval & Modern Astronomy Invention of Telescopes, Models of the Solar System & Universe, Observations by Tycho Brahe, Kepler, Galileo, Herschel and Other,Modern Astronomy	2
Chapter 4	Optical tools for Astronomy - Pin Hole, Binoculars, Telescopes & Imaging.	1
Chapter 5	Mathematical Methods of Observations Angular Measurement, Trigonometric functions, Stellar Parallax	1
Chapter 6	Observational Terminologies Cardinal Directions, Azimuth, Altitude, Measurements using Compass and Hand. Equatorial Co-ordinates, Light years, Magnitude, Colors etc.	2
Unit – 2: Unit 2: Observations of the Solar System		
Chapter 7.	The Sun Ecliptic and the Orientation of the Earth, Seasons - Solstices and Equinox, Observations of the Sun from Earth during seasons. Eclipses, Zero-shadow day, Sunspots	1
Chapter 8	The Moon Earth-Moon system – Phases, Lunar Eclipses, Ecliptic and Lunar Orbital Plane – Nodes, Lunar Month, Full Moon Names	1
Chapter 9.	Inner Planets: Mercury & Venus Observational History, Observational Windows, Appearance, Apparitions, Elongations, Superior Conjunctions, Inferior Conjunctions, Transits.	2
Chapter 10	**Outer Planets** **Outer Planets: Mars, Jupiter & Saturn** Observational History.Observational Windows, Appearance, Frequency of Oppositions Oppositions, Conjunctions, Moons Eclipses.Galilean Moons, Saturn's Rings	2

Unit III Major Astronomy Observations		
Chapter 11	March to June Prominent Stars and Constellations Visible during this period, Methods of Spotting.	2
Chapter 12	June to September Prominent Stars and Constellations Visible during this period, Methods of Spotting.	2
Chapter 13	September to December Prominent Stars and Constellations Visible during this period, Methods of Spotting.	2
Chapter 14	December to March **Pr**ominent Stars and Constellations Visible during this period, Methods of Spotting.	2

Reference Books:

1.The Stargazer's Guide - How to Read Our Night Sky by Emily Winterburn

2. A guide to the Night Sky – Beginner's handbook by P.N. Shankar

3. The Complete Idiot's guide to Astronomy by Christopher De Pree and Alan Axelrod

Text Books

1. P. N. SHANKAR A GUIDE TO THE NIGHT SKY https://www.arvindguptatoys.com/arvindgupta/nightskyshankar.pdf
2. BimanBasu , Joy of Star Watching , National Book Trust of India 2013

References Books

Christopher De Pree :The Complete Idiot's Guide to Astronomy, Penguin USA, 2008

Emily Winterburn ,The Stargazer's Guide: How to Read Our Night Sky, Constable and Robinson, 2008

OE-4: Medical Physics

Duration: 3 hrs /week **Max Marks: 60**

Unit I:	**Human Anatomy and Physiology** Overview of human anatomy - cells, cell structure, type of cells and their functions, tissues, organs, and their functions. Different systems in the humanbody, their structure and function, physiological properties of the circulatory system, digestive system, respiratory system, reproductive system, excretory system, endocrine system and nervous system	(13 hours)
Unit II:	**Physics of Medical Diagnostics** Principle of production of X-rays. Use of X-rays in medical diagnosis, X-ray imaging systems. Computed Tomography (CT): principle and generation of CT. Magnetic Resonance Imaging (MRI): basic principle and image characteristics. Ultrasound Imaging: Interaction of sound waves with body tissues, production of ultrasound, transducers, acoustic coupling, image formation, modes of image display and color Doppler.	(13 hours)
Unit III:	**Physics of Radiotherapy** Clinical aspects of radiation therapy: Biological basis of radiotherapy, radiation sources, radiation dose, time dose fractionation. External beam radiation therapy, radiation therapy modalities, production of radioisotopes, use of radioisotopes in therapy, particle and ion beam radiotherapy. Brachytherapy - principle of brachytherapy and classification of brachytherapy techniques.	(13 hours)

Text Books

1. C. H. Best and N. B. Taylor. A Test in Applied Physiology. Williams and Wilkins Company, Baltimore, 1999.

2. C. K. Warrick. Anatomy and Physiology for Radiographers. Oxford University Press, 2001.

3. Jerrold T. Bushberg. The Essential Physics for Medical Imaging (2ndEdition). Lippincott Williams & Wilkins, 2002.

4. Jean A. Pope. Medical Physics: Imaging. Heinemann Publishers, 2012.

5. Faiz M. Khan and Roger A. Potish. Treatment Planning in Radiation Oncology. Williams and Wilkins, USA, 2003.

6. D. Baltas. The physics of modern brachytherapy for oncology. Taylor and Francis, 2007.

Reference Books

1. J. R. Brobek. Physiological Basis of Medical Practice. Williams and Wilkins, London, 1995.

2. Edward Alcamo, Barbara Krumhardt. Barron's Anatomy and Physiology the Easy Way. Barron's Educational Series, 2004.

3. Lippincott, Anatomy and Physiology. Lippincott Williams & Wilkins, 2002.

4. W. E. Arnould Taylor. A textbook of anatomy and physiology, Nelson Thornes, 1998.

5. G. S. Pant. Advances in Diagnositc Medical Physics. Himalaya Publishing House, 2006.

6. Sabbahaga, Diagnositc Ultrasound applied to OBG. Maryland, 1980.

7. Faiz M Khan. The Physics of Radiation Therapy (3rd edition). Lippincott Williams & Wilkins, USA, 2003.

8. Jatinder R. Palta and T. Rockwell Mackie. Intensity Modulation Radiation Therapy. Medical Physics publishing, Madison, Wisconsin, 2003.

9. AAPM Report No. 72. Basic Applications of Multileaf collimators, AAPM,USA, 2001.

10. AAPM Report No. 91. Management of Respiratory motion in radiation oncology, 2006.

11. CA Joslin, A. Flynn, E. J. hall. Principles and Practice of Brachytherapy. Arnold publications, 2001.

12. Peter Hoskin, Catherine Coyle. Radiotherapy in Practice. Oxford University Press, 2011.

13. W. R. Handee. Medical Radiation Physics. Year Book Medical Publishers Inc., London, 2003.

14. Donald T. Graham, Paul J. Cloke. Principles of Radiological Physics.Churchill Livingstone, 2003.

15. Thomas S. Curry. Christensen',s Physics of Diagnostic Radiology (4th Edition). Lippincott Williams & Wilkins, 1990.

16. Madison. MRI – Perry Sprawls – Medical Physics Publishing. Wisconsin

Open Electives for III Semester

OE-5: OPTICAL INSTRUMENTS

Duration: 3 hrs./week **Max Marks: 60**

Unit 1.	**Basics of Optics** Scope of optics, optical path, laws of reflection and refraction as per Fermat's principle, magnifying glass, Lenses (thick and thin), convex and concave lenses, Lens makers formulae for double concave and convex lenses, lens equation. Focal and nodal points, focal length, image formation, combination of lenses, dispersion of light: Newton's experiment, angular dispersion and dispersion power. Dispersion without deviation. (Expressions need not be derived, but have to be discussed qualitatively).	13
Unit 2.	**Camera and microscopes** Human eye (constitution and working), Photographic camera (principle, construction and working),construction, working and utilities of Simple microscopes, Compound microscope,Electron microscopes, Binocular microscopes **Self study** Experimental determination of magnifying power of a microscope. (Construction part can be discussed through block diagrams)	13
Unit 3.	**Telescopes and Spectrometer** Construction, working and utilities of Astronomical telescopes Terrestrial telescopes Reflecting telescopes, Construction, working and utilities of Eyepieces or Oculars (Huygen, Ramsden's, Gauss) Spectrometer - Construction, working and utilities, measurement of refractive index. **Self study** Telescopes used at different observatories in and outside India.	13
	Activities: Find position and size of the image in a magnifying glass and magnification.Observe rain bows and understand optics. Create a rainbow. Find out what makes a camera to be of good quality.Observe the dispersion of light through prism. Make a simple telescope using magnifying glass and lenses. Learn principle of refraction using prisms. Check bending of light in different substances and find out what matters here.Learn about different telescopes used to see galaxies and their ranges. Many more activities can be tried to learn optics by going through you tubes and webistes such as https://spark.iop.org, http://www.yenka.com, https://publiclab.org etc.	

OE-6: Sports Science

Duration: 3 hrs./week **Max Marks: 60**

Content (Use maths of 10th Std only – Only qualitative discussion)		Hrs
Unit - 1		
Chapter No. 1	**Measurement**: Physical quantities. Standards and Units. International system of Units. Standards of time, length and mass. Precision and significant figures.	o4
Chapter No. 2	**Newton's laws of motion**: Newton's first law. Force, mass. Newton's second law. Newton's third law. Mass and weight. Applications of Newton's laws.	03
Chapter No. 3	**Projectile motion**: Shooting a falling target. Physics behind Shooting, Javelin throw and Discus throw.	03
Topics for self study (If any)	**https://www.real-world-physics-problems.com/physics-of-sports.html**	
Unit - 2		
Chapter No. 4.	**Conservation laws**: Conservation of linear momentum, collisions – elastic and inelastic. Angular momentum. (Physics behind Carom, Billiards, Racing)	04
Chapter No. 5.	**Centre of mass**: Physics behind Cycling, rock climbing, Skating,	02
Chapter No. 6.	**Gravitation**: Origin, Newton's law of gravitation. Archimedes's principle, Buoyancy (Physics behind swimming)	04
Topics for self study (If any)	Archimedes' Principle: Made EASY | Physics in You tube	
Unit - 3		
Chapter No.7	**Food and Nutrition:** Proteins, Vitamins, Fat, Blood pressure. Problems due to the deficiency of vitamins.	04
Chapter No. 8	**Energy:** Different forms of Energy, Conservation of mass-energy.	03
Chapter No . 9	**Physical exercises:** Walking, Jogging and Running, Weight management.	03
Topics for self study (If any)	10 Best Exercises for Everyone – Healthline	
	Suggested Activities	
Activity No. 1	Identify the methods of measurement of time, length and mass from ancient time and build models for them.	02
	Reference : History of measurement - Wikipedia *https://en.wikipedia.org › wiki › History_of_measurem*	
Activity No. 2	Identify Physics principles behind various Sports activities.	01

	https://www.real-world-physics-problems.com/physics-of-sports.html	
Activity No. 3	List the difficulties experienced in Gymnastics, Cycling and weight lifting.	02
Activity No. 4	List the difficulties experienced in swimming.	01
Activity No. 3	List the difficulties experienced in Gymnastics, Cycling and weight lifting.	02
Activity No. 4	List the difficulties experienced in swimming.	01
Activity No. 5	Learn breathing exercises. Reference : 1)Simple Breathing Exercise for Beginners | Swami Ramdev *2) https://www.yogajournal.com*	02
Activity No.6	Write an essay on Physical health v/s Mental health or conduct a debate onPhysical health v/s Mental health.	01

Text Books

Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1	Physics for Entertainment	Yakov Perelman	Createspace Independent Pub.	
2	Physics Everywhere	Yakov Perelman	Prodinnova	2014
3	Mechanics for Entertainment	Yakov Perelman	Prodinnova	2014
4	Handbook of Food and Nutrition	M.Swaminathan	Bangalore Press 2012	2012
5	Food Science	B. Srilakshmi	New Age International Pub	2015

References Books

Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1	Physics	Resnick, Halliday and Krane, Vol 1	Wiley Student Edition.	
2	For the love of Physics	Walter Lewin	Taxmann Publications Private Limited	2012
3	An Introduction to thePhysics of Sports	VassiliosMcInnesSpathopoulos	CreateSpace Independent Publishing Platform	2013

Internet resources
https://www.topendsports.com/biomechanics/physics.htm
https://www.real-world-physics-problems.com/physics-of-sports.html
https://www.healthline.com/
https://www.mayoclinic.org/
https://www.who.int/news-room/

Open Electives for IV Semester

OE-7: NANOTECHNOLOGY

Duration: 3 hrs./week **Max Marks: 60**

Unit 1:	Introduction to nanomaterials Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nano dots, thin films,nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equationInfinite potential well, potential step, potential box, quantum confinement of carriers in 3D,2D, 1D nanostructures and its consequences.	(13hours)
Unit 2:	Synthesis and Characterization of nanostructure materials Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation.Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beamevaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electrodeposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods.MBE growth of quantum dots. X-Ray Diffraction. Optical Microscopy. Scanning ElectronMicroscopy. Transmission Electron Microscopy. Atomic Force Microscopy. ScanningTunneling Microscopy.	(13 hours)
Unit 3:	Properties and applications of nanomaterials Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures andcharging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect bandgap semiconductor nanocrystals. Quantitative treatment of quasiparticles and excitons,charging effects. Radiative processes: General formalization-absorption, emission andluminescence. Optical properties of heterostrctures and nanostructures. Applications ofnanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solarcells). Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching andoptical data storage. Magnetic quantum well; magnetic dots - magnetic data storage.	(13 hours)
References Books: ➢ C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.). ➢ S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company) ➢ K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology(PHI Learning Private Limited). ➢ Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons). ➢ M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook(Elsevier, 2007). ➢ Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011,Cambridge University Press. ➢ Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).		

Student Activities: 1. Synthesis of metal nanoparticles by chemical route. 2. Synthesis of semiconductor nanoparticles. 3. XRD pattern of nanomaterials and estimation of particle size. 4. To study the effect of size on color of nanomaterials. 5. Growth of quantum dots by thermal evaporation. 6. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD. 7. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region. 8. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency. 9. Visit to nearby research labs to study the working of XRD, SEM, UV-Visible Spectrophotometer instruments 10. Visit to nearby research labs for project work and interaction with scientists at IISC, JNCSR, Universities etc.	

OE- 8: ELECTRICAL INSTRUMENTS

Duration: 3 hrs./week **Max Marks: 60**

Content		Hrs
Unit - 1		
Chapter No. 1	Voltage and current sources, Kirchoff's current and voltage laws, loop and nodal analysis of simple circuits with dc excitation. Ammeters,voltmeters: (DC/AC)	03
Chapter No. 2	Representation of sinusoidal waveforms, peak and rms values, power factor. Analysis of single-phase series and parallel R-L-C ac circuits. Three-phase balanced circuits, voltage and current relations in star and delta connections. Wattmeters: Induction type, single phase and three phase wattmeter, Energy meters: AC. Induction type single phase and three phase energy meter	05
Chapter No. 3	Instrument Transformers: Potential and current transformers, ratio and phase angle errors, phasor diagram, methods of minimizing errors; testing and applications.	05
Topics for self study (If any)	Types of switches and Circuits, Safety precautions and rules in handling electrical appliances, Electric shock, first aid for electrical shocks, Fuses, MCB, ELCB and Relays, Filament lamp, Tube light, CFL and LED	
	Suggested Activities	
Activity No. 1	Identify variety of electrical switches and note down their applications/utility. Reference: Weblink/Youtube/Book	
Activity No. 2	Identify the hazards involved in handling electrical circuits and instruments, make a list of safety precautions as well as first aid for electrical shocks. Reference : Weblink/Youtube/Book	
Unit - 2		
Chapter No. 4.	Galvanometers: General principle and performance equations of D'ArsonvalGalvanometers, Vibration Galva nometer and Ballistic Galvanometer.	03
Chapter No. 5.	Potentiometers: DCPotentiometer, Crompton potentio meter, construction, standardization, application. AC Potentio meter, Drysdalepolar potentio meter; standardization, application.	03
Chapter No. 6.	DC/AC Bridges: General equations for bridge balance, measurement of self inductance by Maxwell's bridge (with variable inductance & variable capacitance), Hay's bridge, Owen's bridge, measurement of capacitance by Schearing bridge, errors, Wagner's earthing device, Kelvin's double bridge.	07
Topics for self study (If any)	Importance of grounding and Earthing, Methods for Earthing,	

	Suggested Activities	
Activity No. 3	Make a study of importance of grounding in electrical circuits.	
	Reference : Weblink/Youtube/Book	
Activity No. 4	Prepare a detailed account of various methods of earthing and their utility/applications	
	Reference : Weblink/Youtube/Book	
Unit - 3		
Chapter No.7	Transducer: Strain Gauges, Thermistors, Thermocouples, Linear Variable Differential Transformer (LVDT), Capacitive Transducers, Peizo-Electric transducers, Optical Transducer, Hall Effect Transducer	06
Chapter No. 8	CRO: Block diagram, Sweep generation, vertical amplifiers, use of CRO in measurement of frequency,phase, Amplitude and rise time of a pulse. Digital Multi-meter: Block diagram, principle of operation	03
Chapter No. 9	Basics of lead acid batteries, Lithium Ion Battery , Battery storage capacity, Coulomb efficiency, Numerical of high and low charging rates, Battery sizing.	04
Topics for self study (If any)	Fuses, MCB, ELCB and Relays, Filament lamp, Tube light, CFL and LED	
	Suggested Activities	
Activity No. 5	Prepare a document on evolution of incandescent bulbs to the present day LED lights	
	Reference : Weblink/Youtube/Book	
Activity No.6	Make a comparative study of Fuses, MCB, ELCB and Relays highlighting their useand applications	
	Reference : Weblink/Youtube/Book	

Text Books

AK.Sawhney, ACourse inElec.&Electronics Measurements&Instrumentation **,Dhanpatrai& Co. 1978**
A.D. Helfrick& W.D. Cooper, Modern Electronic Instrumentation and Measurement Techniques **PHI,2016**

References Books

1. D C Kulshreshtha, Basic Electrical Engineering, Mc Graw Hill Publications,**2019**
2. David G Alciatore and Michel B Histand, Introduction to Mechatronics and Measurement Systems, 3rd, Tata McGraw Hill Education Private Limited, New Delhi., 2005
3. Vincent Del Toro, Electrical Engineering Fundamentals Prentice Hall India**2009**

B.Sc in Physics V Semester

Program Name	BSc in Physics	Semester	V
Course Title	**Classical Mechanics and Quantum Mechanics- I (Theory)**		
Course Code	**PHY C9-T**	No. of Credits	**04**
Contact Hours	**60 Hours**	Duration of SEA/Exam	**02 Hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to

- Identify the failure of classical physics at the microscopic level.
- Find the relationship between the normalization of a wave function and the ability to correctly calculate expectation values or probability densities.
- Explain the minimum uncertainty of measuring both observables on any quantum state.
- Describe the time-dependent and time-independent Schrödinger equation for simple potentials like for instance one-dimensional potential well and Harmonic oscillator.
- Apply Hermitian operators, their eigenvalues and eigenvectors to find various commutation and uncertainty relations.

Contents	60 Hrs
Introduction to Newtonian Mechanics: Frames of references, Newton's laws of motion, inertial and non-inertial frames. Mechanics of a particle, Conservation of linear momentum, Angular momentum and torque, conservation of angular momentum, work done by a force, conservative force and conservative energy. **Lagrangian formulation**: Constraints, Holonomic constraints, non-holonomic constraints, Scleronomic and Rheonomic constraints. Generalized coordinates, degrees of freedom, Principle of virtual work, D'Alembert's principle, Lagrange equations. Newton's equation of motion from Lagrange equations, simple pendulum, Atwood's machine and linear harmonic oscillator. **12 Hours** **Activities: 03 Hours**	15
Variational principle: Hamilton's principle, Deduction of Hamilton's principle, Lagrange's equation of motion from Hamilton's principle, Hamilton's principle for non-holonomic systems. **Hamiltonian Mechanics**: The Hamiltonian of a system, Hamilton's equations of motion, Hamilton's equations from variational principle, Integrals of Hamilton's equations, energy integrals, Canonical Transformations, Poison Brackets, fundamental properties and equations of motion in Poison Brackets. **12Hours** **Activities: 03 Hours**	15

Introduction to Quantum Mechanics Brief discussion on failure of classical physics to explain black body radiation, Photoelectric effect, Compton effect, stability of atoms and spectra of atoms. Compton scattering: Expression for Compton shift (With derivation). Matter waves: de Broglie hypothesis of matter waves, Electron microscope, Wave description of particles by wave packets, Group and Phase velocities and relation between them, Experimental evidence for matter waves: Davisson- Germer experiment, G.P Thomson's experiment and its significance. Heisenberg uncertainty principle: Elementary proof of Heisenberg's relation between momentum and position, energy and time, angular momentum and angular position, illustration of uncertainty principle by Gamma ray microscope thought experiment. Consequences of the uncertainty relations: Diffraction of electrons at a single slit, why electron cannot exist in nucleus? Two-slit experiment with photons and electrons. Linear superposition principle as a consequence. **12 Hours** **Activities: 03 Hours**	15
Foundation of Quantum Mechanics Probabilistic interpretation of the wave function - normalization and orthogonality of wave functions, Admissibility conditions on a wave function, Schrödinger equation: equation of motion of matter waves - Schrodinger wave equation for a free particle in one and three-dimension, time-dependent and time-independent wave equations, Probability current density, equation of continuity and its physical significance, Postulates of Quantum mechanics: States as normalized wavefunctions. Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples). Expectation values of operators and their time evolution. Ehrenfest theorem (no derivation), Commutator brackets- Simultaneous Eigen functions, Commutator bracket using position, momentum and angular momentum operators. Particle in a one-dimensional infinite potential well (derivation), degeneracy in three-dimensional case, particle in a finite potential well (qualitative), Transmission across a potential barrier, the tunnel effect (qualitative), scanning tunnelling microscope, One-dimensional simple harmonic oscillator (qualitative) - concept of zero - point energy. **12 Hours** **Activities: 03 Hours**	15

Pedagogy: Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment for Theory	
Assessment type Occasion/	**Marks**
C1	**20**
C2	**20**
Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2	Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer
3	Classical Mechanics, G. Aruldhas, 2008, Prentice-Hall of India Private limited, New Delhi.
4	Classical Mechanics, Takwale and Puranik-1989, Tata Mcgraw Hill, new Delhi
5	Concepts of Modern Physics, Arthur Beiser, McGraw-Hill, 2009.
6	Physics for Scientists and Engineers with Modern Physics, Serway and Jewett, 9th edition, Cengage Learning, 2014.
7	Quantum Physics, Berkeley Physics Course Vol. 4. E.H. Wichman, Tata McGraw-Hill Co., 2008.
8	Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, McGraw Hill, 2003.
9	P M Mathews and K Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill publication, ISBN: 9780070146174.
10	Ajoy Ghatak, S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer Publication,ISBN 978-1-4020-2130-5.
11	Modern Physics; R.Murugeshan & K.Sivaprasath; S. Chand Publishing.
12	G Aruldhas, Quantum Mechanics, Phi Learning Private Ltd., ISBN: 97881203363.
13	Gupta, Kumar & Sharma, Quantum Mechanics, Jai Prakash Nath Publications.
14	Physics for Degree Students B.Sc., Third Year, C.L.Arora and P.S.Hemne, 1st edition, S.Chand & Company Pvt. Ltd., 2014.

Course Title	Classical Mechanics and Quantum Mechanics- I (Practical)	Practical Credits	02
Course Code	PHY C10-P	Contact Hours	04 Hours
Formative Assessment	25 Marks	Summative Assessment	25 Marks

Practical Content

Lab experiments: (at least 4 experiments from 1-8 and 4 experiments from 9-18)

1) To determine 'g', the acceleration due to gravity, at a given place, from the L – T^2 graph, for a simple pendulum.

2) Studying the effect of mass of the bob on the time period of the simple pendulum.

[Hint: With the same experimental set-up, take a few bobs of different materials (different masses) but of same size. Keep the length of the pendulum same for each case. Starting from a small angular displacement of about 10° find out, in each case, the time period of the pendulum, using bobs of different masses. Does the time period depend on the mass of the pendulum bob? If yes, then see the order in which the change occurs. If not, then do you see an additional reason to use the pendulum as a time measuring device.

3) Studying the effect of amplitude of oscillation on the time period of the simple pendulum.

[Hint: With the same experimental set-up, keep the mass of the bob and length of the pendulum fixed. For measuring the angular amplitude, make a large protractor on the cardboard and have a scale marked on an arc from 0° to 90° in units of 5°. Fix it on the edge of a table by two drawing pins such that its 0°-line coincides with the suspension thread of the pendulum at rest. Start the pendulum oscillating with a very large angular amplitude (say 70°) and find the time period T of the pendulum. Change the amplitude of oscillation of the bob in small steps of 5° or 10° and determine the time period in each case till the amplitude becomes small (say 5°). Draw a graph between angular amplitude and T. How does the time period of the pendulum change with the amplitude of oscillation? How much does the value of T for A = 10° differ from that for A= 50° from the graph you have drawn? Find at what amplitude of oscillation, the time period begins to vary? Determine the limit for the pendulum when it ceases to be a simple pendulum.]

4) Determine the acceleration of gravity is to use an Atwood's machine/Fly Wheel.

5) Study the conservation of energy and momentum using projectile motion.

6) Verification of the Principle of Conservation of Linear Momentum

7) A code in Python-Scilab to plot and analyze the trajectory of projectile motion

8) Determination of acceleration due to gravity by Stoke's method

9) Determination of Planck constant and work function of the material of the cathode using Photo-electric cell.

10) To study the spectral characteristics of a photo-voltaic cell (Solar cell).

11) Determination of electron charge 'e' by Millikan's Oil drop experiment.

12) To study the characteristics of solar cell.

13) To find the value of e/m for an electron by Thomson's method using bar magnets.

14) To determine the value of e/m for an electron by magnetron method.

15) To study the tunnelling in Tunnel Diode using I-V characteristics.

16) Determination of quantum efficiency of Photodiode.

17) A code in Python-Scilab to find the first seven eigen states and eigen functions of Linear Harmonic Oscillator by solving the Schrödinger equation.

18) A code in Python-Scilab to plot and analyse the wavefunctions for particle in an infinite potential well.

Lab experiments: (at least 4 experiments from 1-8 and 4 experiments from 9-18)

19) To determine 'g', the acceleration due to gravity, at a given place, from the L – T^2 graph, for a simple pendulum.

20) Studying the effect of mass of the bob on the time period of the simple pendulum.

[Hint: With the same experimental set-up, take a few bobs of different materials (different masses) but of same size. Keep the length of the pendulum same for each case. Starting from a small angular displacement of about 10° find out, in each case, the time period of the pendulum, using bobs of different masses. Does the time period depend on the mass of the pendulum bob? If yes, then see the order in which the change occurs. If not, then do you see an additional reason to use the pendulum as a time measuring device.

21) Studying the effect of amplitude of oscillation on the time period of the simple pendulum.

[Hint: With the same experimental set-up, keep the mass of the bob and length of the pendulum fixed. For measuring the angular amplitude, make a large protractor on the cardboard and have a scale marked on an arc from 0° to 90° in units of 5°. Fix it on the edge of a table by two drawing pins such that its 0°-line coincides with the suspension thread of the pendulum at rest. Start the pendulum oscillating with a very large angular amplitude (say 70°) and find the time period T of the pendulum. Change the amplitude of oscillation of the bob in small steps of 5° or 10° and determine the time period in each case till the amplitude becomes small (say 5°). Draw a graph between angular amplitude and T. How does the time period of the pendulum change with the amplitude of oscillation? How much does the value of T for A = 10° differ from that for A= 50° from the graph you have drawn? Find at what amplitude of oscillation, the time period begins to vary? Determine the limit for the pendulum when it ceases to be a simple pendulum.]

22) Determine the acceleration of gravity is to use an Atwood's machine/Fly Wheel.

23) Study the conservation of energy and momentum using projectile motion.

24) Verification of the Principle of Conservation of Linear Momentum

25) A code in Python-Scilab to plot and analyze the trajectory of projectile motion

26) Determination of acceleration due to gravity by Stoke's method

27) Determination of Planck constant and work function of the material of the cathode using Photo-electric cell.

28) To study the spectral characteristics of a photo-voltaic cell (Solar cell).

29) Determination of electron charge 'e' by Millikan's Oil drop experiment.

30) To study the characteristics of solar cell.

31) To find the value of e/m for an electron by Thomson's method using bar magnets.

32) To determine the value of e/m for an electron by magnetron method.

33) To study the tunnelling in Tunnel Diode using I-V characteristics.

34) Determination of quantum efficiency of Photodiode.

35) A code in Python-Scilab to find the first seven eigen states and eigen functions of Linear Harmonic Oscillator by solving the Schrödinger equation.

36) A code in Python-Scilab to plot and analyse the wavefunctions for particle in an infinite potential well.

Pedagogy: Demonstration/Experiential Learning / Self Directed Learning etc.

Formative Assessment for Practical

Assessment type	Occasion/	Marks
C1		10
C2		15
Total		**25 Marks**

Formative Assessment as per UNIVERSITY guidelines are compulsory

References	
1	B.Sc Practical Physics by C.L Arora.
2	B.Sc Practical Physics by Harnam Singh and P.S Hemne.
3	Practical Physics by G.S Squires.
4	Scilab Manual for CC-XI: Quantum Mechanics &Applications (32221501) by Dr Neetu Agrawal, Daulat Ram College of Delhi.
5	Scilab Textbook Companion for Quantum Mechanics by M. C. Jain.
6	Computational Quantum Mechanics using Scilab, BIT Mesra.
7	Advanced Practical Physics for Students by Worsnop B L and Flint H T.

Curriculum

Program Name	BSc in Physics	**Semester**	**V**
Course Title	**Elements of Atomic, Molecular & Laser Physics (Theory)**		
Course Code	**PHY C11-T**	**No. of Credits**	**04**
Contact Hours	**60 Hours**	**Duration of SEA/Exam**	**02 Hours**
Formative Assessment Marks	**40**	**Summative Assessment Marks**	**60**

Course Pre-requisite (s): PUC Science Knowledge

Course Outcomes (COs): After the completion of the course, the student will be able to

- Describe atomic properties using basic atomic models.
- Interpret atomic spectra of elements using vector atom model.
- Interpret molecular spectra of compounds using basics of molecular physics.
- Explain laser systems and their applications in various fields.

Contents	**60 Hours**

Basic Atomic models Thomson's atomic model; Rutherford atomic model – Model, Theory of alpha particle scattering, Rutherford scattering formula; Bohr atomic model – postulates, Derivation of expression for radius, total energy of electron; Origin of the spectral lines; Spectral series of hydrogen atom; Effect of nuclear motion on atomic spectra - derivation; Ritz combination principle; Correspondence principle; Critical potentials – critical potential, excitation potential and ionisation potential; Atomic excitation and its types, Franck-Hertz experiment; Sommerfeld's atomic model – model, Derivation of condition for allowed elliptical orbits. **12 Hours** **Activities:** **03 Hours** 1. Students to estimate radii of orbits and energies of electron in case of hydrogen atom in different orbits and plot the graph of radii / energy versus principal quantum number 'n'. Analyze the nature of the graph and draw the inferences. 2. Students to search critical, excitation and ionisation potentials of different elements and plot the graph of critical /excitation / ionisation potentials versus atomic number/mass number/neutron number of element. Analyze the nature of the graph and draw the inferences.	15
Vector atomic model and optical spectra Vector atom model – model fundamentals, spatial quantisation, spinning electron; Quantum numbers associated with vector atomic model; Coupling schemes – L-S and j-j schemes; Pauli's exclusion principle; Magnetic dipole moment due to orbital motion of electron – derivation; Magnetic dipole moment due to spin motion of electron; Lande g-factor and its calculation for different states; Stern-Gerlach experiment – Experimental arrangement and Principle; Fine structure of spectral lines with examples; Spin-orbit coupling/Spin-Orbit Interaction – qualitative; Optical spectra – spectral terms, spectral notations, selection rules, intensity rules; Fine structure of the sodium D-line; Zeeman effect: Types, Experimental study and classical theory of normal Zeeman effect, Zeeman shift expression (no derivation), examples; Stark	15

effect: Experimental study, Types and examples. **12Hours** **Activities:** **03 Hours** 1. Students to couple a p-state and s-state electron via L-S and j-j coupling schemes for a system with two electrons and construct vector diagrams for each resultant. Analyze the coupling results and draw the inferences. 2. Students to estimate magnetic dipole moment due to orbital motion of electron for different states $^2P_{1/2}$, $^2P_{3/2}$, $^2P_{5/2}$, $^2P_{7/2}$, $^2P_{9/2}$ and $^2P_{11/2}$ and plot the graph of dipole moment versus total orbital angular momentum "J'. Analyze the nature of the graph and draw the inferences.	
Molecular Physics Types of molecules based on their moment of inertia; Types of molecular motions and energies; Born-Oppenheimer approximation; Origin of molecular spectra; Nature of molecular spectra; Theory of rigid rotator – energy levels and spectrum, Qualitative discussion on Non-rigid rotator and centrifugal distortion; Theory of vibrating molecule as a simple harmonic oscillator – energy levels and spectrum; Electronic spectra of molecules – fluorescence and phosphorescence; Raman effect – Stoke's and anti-Stoke's lines, characteristics of Raman spectra, classical and quantum approaches, Experimental study of Raman effect; Applications of Raman effect. **12 Hours** **Activities:** **03 Hours** 1. Students to estimate energy of rigid diatomic molecules CO, HCl and plot the graph of rotational energy versus rotational quantum number 'J'. Analyse the nature of the graph and draw the inferences. Also students study the effect of isotopes on rotational energies. 2. Students to estimate energy of harmonic vibrating molecules CO, HCl and plot the graph of vibrational energy versus vibrational quantum number 'v'. Analyse the nature of the graph and draw the inferences.	15
Laser Physics Ordinary light versus laser light; Characteristics of laser light; Interaction of radiation with matter - Induced absorption, spontaneous emission and stimulated emission with mention of rate equations; Einstein's A and B coefficients – Derivation of relation between Einstein's coefficients and radiation energy density; Possibility of amplification of light; Population inversion; Methods of pumping; Metastable states; Requisites of laser – energy source, active medium and laser cavity; Difference between Three level and four level lasers with examples; Types of lasers with examples; Construction and Working principle of Ruby Laser and He-Ne Laser; Application of lasers (qualitative) in science & research, isotope separation, communication, fusion, medicine, industry, war and space. **12 Hours** **Activities:** **03 Hours** 1. Students to search different lasers used in medical field (ex: eye surgery, endoscopy, dentistry etc.), list their parameters and analyse the need of these parameters for specific application, and draw the inferences. Students also make the presentation of the study. 2. Students to search different lasers used in defense field (ex: range finding, laser weapon, etc.), list their parameters and analyse the need of these parameters for specific application, and draw the inferences. Students also make the presentation of the study.	15

Pedagogy: Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/

Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment for Theory	
Assessment type Occasion/	**Marks**
Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	Modern Physics, R. Murugeshan, Kiruthiga Sivaprakash, Revised Edition, 2009, S. Chand & Company Ltd.
2	Atomic & Molecular spectra: Laser, Raj Kumar, Revised Edition, 2008, Kedar Nath Ram Nath Publishers, Meerut.
3	Atomic Physics, S.N. Ghoshal, Revised Edition, 2013, S. Chand & Company Ltd.
4	Concepts of Atomic Physics, S.P. Kuila, First Edition, 2018, New Central Book Agency (P) Ltd.
5	Concepts of Modern Physics, Arthur Beiser, Seventh Edition, 2015, Shobhit Mahajan, S. Rai Choudhury, 2002, McGraw-Hill.
6	Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash, Fourth Edition, 2008, Tata McGraw-Hill Publishers.
7	Elements of Spectroscopy – Atomic, Molecular and Laser Physics, Gupta, Kumar and Sharma, 2016, Pragati Publications.

Course Title	**Elements of Atomic, Molecular & Laser Physics (Practical)**	**Practical Credits**	**02**
Course Code	**PHY C12-P**	**Contact Hours**	**04 Hours**
Formative Assessment	**25 Marks**	**Summative Assessment**	**25 Marks**
Practical Content			

NOTE: Students have to perform at-least EIGHT Experiments from the list below

LIST OF EXPERIMENTS

1. To determine Planck's constant using Photocell.
2. To determine Planck's constant using LED.
3. To determine wavelength of spectral lines of mercury source using spectrometer.
4. To determine the value of Rydberg's constant using diffraction grating and hydrogen discharge tube.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine fine structure constant using fine structure separation of sodium D-lines using a plane diffraction grating.
7. To determine the ionization potential of Mercury/Xenon.
8. To determine the absorption lines in the rotational spectrum of Iodine vapour.
9. To determine the force constant and vibrational constant for the iodine molecule from its absorption spectrum.
10. To determine the wavelength of laser using diffraction by single slit/double slits.
11. To determine wavelength of He-Ne laser using plane diffraction grating.
12. To determine angular spread of He-Ne laser using plane diffraction grating.
13. Study of Raman scattering by CCl_4 using laser and spectrometer/CDS.
14. To determine the diameter of the given wire by LASER diffraction.
15. Analysis of Stellar Spectra.
16. Analysis of Band Spectra.

Pedagogy: Demonstration/Experiential Learning / Self Directed Learning etc.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Total	**25 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	Practical Physics, D.C. Tayal, First Millennium Edition, 2000, Himalaya Publishing House.
2	B.Sc. Practical Physics, C.L. Arora, Revised Edition, 2007, S. Chand & Comp.Ltd.
3	An Advanced Course in Practical Physics, D. Chatopadhyaya, P.C. Rakshith, B. Saha, Revised Edition, 2002, New Central Book Agency Pvt. Ltd.
4	Physics through experiments, B. Saraf, 2013, Vikas Publications.

B.Sc in Physics VI Semester

Curriculum

Program Name	BSc in Physics	**Semester**	**VI**
Course Title	**Elements of Condensed Matter & Nuclear Physics(Theory)**		
Course Code	**PHY C14 - T**	**No. of Credits**	**4**
Contact Hours	**60 Hours**	**Duration of SEA/Exam**	**2 Hours**
Formative Assessment Marks	**40**	**Summative Assessment Marks**	**60**

4

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

- Explain the basic properties of nucleus and get the idea of its inner information.
- Understand the concepts of binding energy and binding energy per nucleon v/s mass number graph.
- Describe the processes of alpha, beta and gamma decays based on well-established theories.
- Explain the basic aspects of interaction of gamma radiation with matter by photoelectric effect, Compton scattering and pair production.
- Explain the different nuclear radiation detectors such as ionization chamber, Geiger-Mueller counter etc.
- Explain the basic concept of scintillation detectors, photo-multiplier tube and semiconductor detectors.

Contents	**60 Hours**
Crystal systems and X-rays: Crystal structure**:** Space Lattice, Lattice translational vectors, Basis of crystal structure, Types of unit cells, primitive, non-primitive cells.. Seven crystal system, Coordination numbers, Miller Indices, Expression for inter planner spacing. **X Rays**: Production and properties of X rays, Coolidge tube, Continuous and characteristic X-ray spectra; Moseley's law. **X-Ray diffraction**, Scattering of X-rays, Bragg's law. **Crystal diffraction:** Bragg's X-ray spectrometer- powder diffraction method, Intensity vs 2θ plot (qualitative). **Free electron theory of metals:** Classical free electron model (Drude-Lorentz model), expression for electrical and thermal conductivity, Weidman-Franz law, Failure of classical free electron theory; Quantum free electron theory, Fermi level and Fermi energy, Fermi-Dirac distribution function (expression for probability distribution F(E), statement only); Fermi Dirac distribution at T=0 and $E<E_f$, at $T\neq 0$ and $E>E_f$, F(E) vs E plot at T = 0 and $T\neq 0$. Density of states for free electrons (statement only, no derivation). Qualitative discussion of lattice vibration and concept of Phonons. Specific heats of solids: Classical theory, Einstein's and Debye's theory of specific heats. Hall Effect in metals. **12 HOURS** **ACTIVITIES:** **03 HOURS**	15
Magnetic Properties of Matter, Dielectrics and Superconductivity **Magnetic Properties of Matter** Review of basic formulae: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility, magnetization (M), Classification of Dia, Para, and ferro magnetic materials;	15

Langevin Classical Theory of dia – and Paramagnetism. Curie's law, Ferromagnetism and Ferromagnetic Domains (qualitative). Discussion of B-H Curve. Hysteresis and Energy Loss, Hard and Soft magnetic materials **Dielectrics**: Static dielectric constant, polarizability (electronic, ionic and orientation), calculation of Lorentz field (derivation), Clausius-Mosotti equation (derivation), dielectric loss. Piezo electric effect, cause, examples and applications. **Superconductivity:** Definition, Experimental results – Zero resistivity and Critical temperature– The critical magnetic field – Meissner effect, Type I and type II superconductors. **12 Hours** **ACTIVITIES: 03 Hours**	
General Properties of Nuclei: Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, main features of binding energy versus mass number curve, angular momentum, parity, magnetic moment, electric moments **Radioactivity decay:** Radioactivity: definition of radioactivity, half-life, mean life, radioactivity equilibrium **(**a) Alpha decay: basics of α-decay processes, theory of α emission (brief), Gamow factor, Geiger-Nuttall law. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays' emission & kinematics, internal conversion (Definition). **12 Hours** **ACTIVITIES: 03 Hours**	15
Interaction of Nuclear Radiation with matter: Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, Energy loss due to ionization (quantitative description of Bethe Block formula), energy loss of electrons, introduction of Cerenkov radiation **Detector for Nuclear Radiations**: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility) qualitative only, Accelerators: Cyclotrons and Synchrotrons. **12 Hours** **ACTIVITIES: 03 Hours**	15
Suggested Activities:	
1) Students to construct seven crystal systems with bamboo sticks and rubber bands. Use foam ball as atoms and study the BCC and FCC systems. 2)Students to search the characteristic X ray wavelength of different atoms/elements and plot characteristic wavelength vs atomic number and analyse the result and draw the inference. 3)Magnetic field lines are invisible. Students to trace the magnetic field lines using bar magnet and needle compass. https://nationalmaglab.org/magnet-academy/try-this-at- home/drawing-magnetic-field-lines/ , 4)Using vegetable oil and iron fillings students to make ferrofluids and see how it behaves in the presence of magnetic field. https://nationalmaglab.org/magnet-academy/try-this-at-home/making-ferrofluids/ 1) Study the decay scheme of selected alpha, beta & gamma radioactive sources with the help of standard nuclear data book. 2) Calculate binding energy of some selected light, medium and heavy nuclei. Plot the graph of binding energy versus mass number A 3) Study the decay scheme of standard alpha, beta and gamma sources using nuclear data book. 4) Make the list of alpha emitters from Uranium series and Thorium series. Search the kinetic energy of alpha particle emitted by these alpha emitters. Collect the required data such as half life or decay constant. Verify Geiger-Nuttal in each series. 5) Study the Z dependence of photoelectric effect cross section. 6) Study the Z dependence of common cross section for selected gamma energies and selected elements through theoretical calculation. 7) List the materials and their properties which are used for photocathode of PMT.	

8)	Study any two types of PMT and their advantages and disadvantages.	

Pedagogy: Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References

1. Solid State Physics-R. K. Puri and V.K. Babber., S.Chand publications,1st Edition(2004).
2. Fundamentals of Solid State Physics-B.S.Saxena,P.N. Saxena,Pragati prakashan Meerut(2017).
3. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
4. Nuclear Physics, Irving Kaplan, Narosa Publishing House
1. Introduction to solid State Physics, ***Charles Kittel***, VII edition, (**1996**)
5. Solid State Physics- **A J Dekker**, MacMillan India Ltd, (**2000**)
6. Essential of crystallography**, M A Wahab**, Narosa Publications (**2009)**
7. Solid State Physics-**S O Pillai**-New Age Int. Publishers (**2001**).
8. Concepts of nuclear physics by Bernard L. Cohen. (Tata McGraw Hill, 1998).
9. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
10. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
11. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (Institute of Physics (IOP) Publishing, 2004).
12. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
13. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

Course Title	**Elements of Condensed Matter & Nuclear Physics (Practical)**	**Practical Credits**	**02**
Course Code	**PHY C15 – P**	**Contact Hours**	**04 Hours**
Formative Assessment	**25 Marks**	**Summative Assessment**	**25 Marks**
Practical Content			

(At least 4 experiments from CMP and 4 experiments from NP are to be performed)

CONDENSED MATTER PHYSICS(CMP)

1. Hall Effect in semiconductor: determination of mobility, hall coefficient.
2. Energy gap of semiconductor (diode/transistor).
3. Temperature coefficient of resistance of a Thermistor.
4. Fermi Energy of Copper.
5. Analysis of X-ray diffraction spectra and calculation of lattice parameter.
6. Specific Heat of Solid by Electrical Method
7. Determination of Dielectric Constant of polar liquid.
8. Determination of dipole moment of organic liquid
9. B-H Curve Using CRO.
10. Determination of particle size from XRD pattern using Debye-Scherrer formula.
11. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
12. Measurement of susceptibility of paramagnetic solid (Gouy's Method)
13. Determination of particle size from XRD pattern using Williamson Hall Plot.

NUCLEAR PHYSICS(NP)

1. Study the characteristics of Geiger-Mùller Tube. Determine the threshold voltage, plateau region and operating voltage.
2. Study of inverse square law of gamma rays using GM tube.
3. Detrmination of range of electrons in aluminium using GM Counter.
4. Study the absorption of beta particles in aluminium foils using GM counter. Determine mass attenuation coefficient of Aluminium foils.
5. Study the absorption of beta particles in thin copper foils using G M counter and determine mass attenuation coefficient.
6. Study the attenuation of gamma rays in lead foils using Cs-137 source and G M counter. Calculate mass attenuation coefficient of Lead for Gamma.
7. Determine the end point energy of Tl-204 source by studying the absorption of beta particles in aluminium foils.
   Study the attenuation of absorption of gamma rays in polymeric materials using Cs-137 source and G M counter.

Pedagogy: ~~Demonstration/Experiential Learning / Self Directed Learning~~ etc.

Formative Assessment for Practical	
Assessment type **Occasion/**	**Marks**
Total	**25 Marks**

Formative Assessment as per UNIVERSITY guidelines are compulsory

References

1	IGNOU : Practical Physics Manual
2	Saraf : Experiment in Physics, Vikas Publications
3	S.P. Singh : Advanced Practical Physics
4	Melissons : Experiments in Modern Physics
5	Misra and Misra, Physics Lab. Manual, South Asian publishers, (**2000**)
6	Gupta and Kumar, Practical physics, Pragati prakashan, (**1976**)

Curriculum

Program Name	BSc in Physics	**Semester**	**VI**
Course Title	**Electronic Instrumentation & Sensors (Theory)**		
Course Code:	**PHY C16 - T**	**No. of Credits**	**04**
Contact Hours	**60 Hours**	**Duration of SEA/Exam**	**2 Hours**
Formative Assessment Marks	**40**	**Summative Assessment Marks**	**60**

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

- Identify different types of tests and measuring instruments used in practice and understand their basic working principles.
- Get hands on training in wiring a circuit, soldering, making a measurement using an electronic circuit used in instrumentation.
- Have an understanding of the basic electronic components viz., resistors, capacitors, inductors, discrete and integrated circuits, colour codes, values and pin diagram, their practical use.
- Understanding of the measurement of voltage, current, resistance value, identification of the terminals of a transistor and ICs.
- Identify and understand the different types of transducers and sensors used in robust and hand-held instruments.
- Understand and give a mathematical treatment of the working of rectifiers, filter, data converters and different types of transducers.
- Connect the concepts learnt in the course to their practical use in daily life.
- Develop basic hands-on skills in the usage of oscilloscopes, multimeters, rectifiers, amplifiers, oscillators and high voltage probes, generators and digital meters.
- Servicing of simple faults of domestic appliances: Iron box, immersion heater, fan, hot plate, battery charger, emergency lamp and the like.

Contents	**60Hours**
Power supply AC power and its characteristics, Single phase and three phase, Need for DC power supply and its characteristics, line voltage and frequency, Rectifier bridge, Filters: Capacitor and inductor filers, L-section and π-section filters, ripple factor, electronic voltage regulators, stabilization factor, voltage regulation using ICs. **Basic electrical measuring instruments** Cathode ray oscilloscope- Block diagram, basic principle, electron beam, CRT features, signal display. Basic elements of digital storage oscilloscopes. Basic DC voltmeter for measuring potential difference, Extending Voltmeter range, AC voltmeter using rectifiers, Basic DC ammeter, requirement of a shunt, Extending of ammeter ranges. *Topics for self-study:* *Average value and RMS value of current, Ripple factor, Average AC input power and DC output power, efficiency of a DC power supply. Multirange voltmeter and ammeter.* **12 Hours** **ACTIVITIES:** **03 Hours** **Activities**	15

Design and wire your own DC regulated power supply. Power output: 5 V, 10 V, ± 5 V. Components required: A step down transformer, semiconductor diodes (BY126/127), Inductor, Capacitor, Zener diode or 3-pin voltage regulator or IC. Measure the ripple factor and efficiency at each stage. Tabulate the result. 1. Extend the range of measurement of voltage of a voltmeter (analog or digital) using external component and circuitry. Design your own circuit and report. 2. Measure the characteristics of the signal waveform using a CRO and function generator. Tabulate the frequency and time period. Learn the function of Trigger input in an CRO. 3. Learn to use a Storage Oscilloscope for measuring the characteristics of a repetitive input signal. Convince yourself how signal averaging using Storage CRO improves S/N ratio.	
Wave form generators and Filters Basic principle of standard AF signal generator: Fixed frequency and variable frequency, AF sine and square wave generator, basic Wein-bridge network and oscillator configuration, Triangular and saw tooth wave generators, circuitry and waveforms. Passive and active filters. Fundamental theorem of filters, Proof of the theorem by considering a symmetrical T-network. Types of filters, Circuitry and Cut-off frequency and frequency response of Passive (RC) and Active (op-amp based) filters: Low pass, high pass and band pass. **12 Hours** **ACTIVITIES: 03 Hours** **Activities** 1. Measure the amplitude and frequency of the different waveforms and tabulate the results. Required instruments: A 10 MHz oscilloscope, Function generators (sine wave and square wave). 2. Explore where signal filtering network is used in real life. Visit a nearby telephone exchange and discuss with the Engineers and technicians. Prepare a report. 3. Explore op-amp which works from a single supply biasing voltage (+15V). Construct an inverting/non-inverting amplifier powered by a single supply voltage instead of dual or bipolar supply voltage. 4. Op-amp is a linear (analog) IC. Can it be used to function as logic gates? Explore, construct and implement AND, OR NAND and NOR gate functions using op-amps. Verify the truth table. Hint: LM3900 op-amp may be used. The status of the output may be checked by LED.	15
Data Conversion and display Digital to Analog (D/A) and Analog to Digital (A/D) converters – A/D converter with pre-amplification and filtering. D/A converter - Variable resistor network, Ladder type (R-2R) D/A converter, Op-amp based D/A converter. Digital display systems and Indicators- Classification of displays, Light Emitting Diodes (LED) and Liquid Crystal Display (LCD) – Structure and working. Data Transmission systems – Advantages and disadvantages of digital transmission over analog transmission, Pulse amplitude modulation (PAM), Pulse time modulation (PTM) and Pulse width modulation (PWM)- General principles. Principle of Phase Sensitive Detection (PSD). *Topic for self-study*: *Lock-in amplifier and its application, phase locked loop.* **12 Hours** **ACTIVITIES: 03 Hours** **Activities** 1. Explore where modulation and demodulation technique is employed in real life. Visit a Radio broadcasting station. (Aakashavani or Private). Prepare a report on different AM and FM stations. 2. Explore and find out the difference between a standard op-amp and an instrumentation op-amp. Compare the two and prepare a report.	15
Transducers and sensors Definition and types of transducers. Basic characteristics of an electrical transducer, factors governing the selection of a transducer, Resistive transducer-potentiometer, Strain gauge and types (general description), Resistance thermometer-platinum resistance thermometer.	15

Thermistor. Inductive Transducer-general principles, Linear Variable Differential Transducer (LDVT)- principle and construction, Capacitive Transducer, Piezo-electric transducer, Photoelectric transducer, Photovoltaic cell, photo diode and phototransistor – principle and working. **12 Hours** **ACTIVITIES: 03 Hours** **Activities** 1. Construct your own thermocouple for the measurement of temperature with copper and constantan wires. Use the thermocouple and a Digital multimeter (DMM). Record the emf (voltage induced) by maintaining one of the junctions at a constant temperature (say at 0^{o} C, melting ice) and another junction at variable temperature bath. Tabulate the voltages induced and temperatures read out using standard chart (Chart can be downloaded from the internet). 2. Observe a solar water heater. Some solar water heaters are fitted with an anode rod (alloy of aluminium). Study why it is required. Describe the principle behind solar water heater.	

Pedagogy: Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self Directed Learning etc.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References

1. Physics for Degree students (Third Year) – C.L. Arora and P.S. Hemne, S, Chand and Co. Pvt. Ltd. 2014 (For Unit-1, Power supplies)
2. Electronic Instrumentation, 3rd Edition, H.S. Kalsi, McGraw Hill Education India Pvt. Ltd. 2011 (For rest of the syllabus)
3. Instrumentation – Devices and Systems (2nd Edition)– C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill Education Pvt. Ltd. (Especially for circuitry and analysis of signal generators and filters)

Course Title	**Electronic Instrumentation & Sensors (Practical)**	**Practical Credits**	**02**
Course Code	**PHY C17 – P**	**Contact Hours**	**04 Hours**
Formative Assessment	**25 Marks**	**Summative Assessment**	**25 Marks**

Practical Content
List of experiments (At least 8 experiments to be performed) 1. Bridge rectifier with and without filter 2. Phase measurement in LCR circuit using CRO 3. Study of Zener diode as a voltage regulator. 4. RC low pass and high pass filters. 5. Calibration of a low range voltmeter using a potentiometer 6. Calibration of an ammeter using a potentiometer 7. Study of Wien bridge oscillator 8. Study the frequency response of a first order op-amp low pass filter 9. Study the frequency response of a first order op-amp high pass filter 10. Study of LDR Characteristics. 11. Study the characteristics of *pn*-junction of a solar cell and determine its efficiency. 12. Study the illumination intensity of a solar cell using a standard photo detector (e.g., lux meter). 13. Determine the coupling coefficient of a piezo-electric crystal. 14. Study the amplitude modulation using a transistor. 15. Performance analysis of A/D and D/A converter using resistor ladder network and op-amp.

Pedagogy: Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ ExperientialLearning / Self Directed Learning etc.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Total	**25 Marks**
Formative Assessment as per University guidelines are compulsory	

References
1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House. 2. B.Sc. Practical Physics, C.L. Arora (Revised Edition), S. Chand and Co. Ltd. 2007 3. Practical Physics, D.C. Tayal, First Millennium Edition, Himalaya Publishing House, 2000

Employability and skill development
The whole syllabus is prepared with a focus on employability.
Skill development achieved: Fundamental understanding of the working of test and measuring instruments. Operating and using them for measurements. Servicing of laboratory equipment for simple cable faults, loose contacts and discontinuity.
Job opportunities: Lab Assistant/Scientific Assistant in hospitals, R and D institutions, educational institutions.

Question Paper Pattern
DSC Papers

I to VI SEMESTER - THEORY

Duration: $2\frac{1}{2}$ Hrs **Maximum marks: 60**

PART- A

I Answer the following questions: **4 x 10 = 40**

SIX questions have to be set and FOUR questions to be answered.
(ONE question is a must from each unit.)

PART – B

II Answer any THREE questions: **3 x 4 = 12**

(Problems/Application Oriented Questions)
FOUR questions have to be set THREE questions to be answered.
(ONE question from each unit has to be given.)

PART - C

III Answer any FOUR questions: **4 x 2 = 08**

SIX questions have to be set and FOUR questions to be answered.
(ONE question is a must from each unit.)

Question Paper Pattern

Open Elective Papers

I to IV SEMESTER

THEORY

Duration: 2Hrs **Maximum marks: 60**

PART- A

I Answer any SIX questions: **6 x 10 = 60**

NINE questions has to be set and SIX questions to be answered
(THREE questions from each unit have to be set. Each question may include sub questions of both theory and numerical.)

Practical Examination-Scheme of Valuation

I to IV Semesters

Duration: 3 Hours **Max. Marks: 25**

Content	Marks
Diagram/Circuit diagram	02
Formula with units, explanation of terms	02
Circuit connections and handling	03
Tabular column with units	02
Observations/method of taking reading/Tabulation	04
Calculation	05
Result with accuracy and unit	02
Viva	05
Total marks for practical examination	**25**

PANEL OF EXAMINERS

SL.NO	NAME OF EXAMINER	NAME OF THE COLLEGE	CONTACT NO
1.	Sridevi Dyvanagoudar	JSS College, Nanjanagud	
2.	Vinay kumar.L	JSS College ooty road, Mysore	
3.	Karthik	JSS College ooty road, Mysore	
4.	Chaithra	JSS College ooty road, Mysore	
5.	Shwetha U S	JSS College ooty road, Mysore	
6.	Mallikarjunswamy	JSS College, chamarajanagar	
7.	Lakshmi S	JSS College, chamarajanagar	
8.	C. Nagesh babu	Yuvaraja's College, Mysore	
9.	Dr. B.C. Manjunath	Yuvaraja's College, Mysore	
10.	T.Sadashiviah	Yuvaraja's College, Mysore	
11.	Dr.Somashekarappa	Yuvaraja's College, Mysore	
12.	Sushma	Yuvaraja's College, Mysore	
13.	Sunitha Rani	Yuvaraja's College, Mysore	
14.	Sukhanth	Yuvaraja's College, Mysore	
15.	Dr S R Kumaraswamy	Maharani's Science College, Mysore	
16.	Dr. Manjunath M.V.	Maharani's Science College, Mysore	
17.	Dr. G.B.Thippeswamy	Maharani's Science College,Mysore	
18.	Dr.Krishnamohan	Maharani's Science College,Mysore	
19.	Nagaraju	Maharani's Science College,Mysore	
20.	Rashmi P E	Maharani's Science College,Mysore	
21.	Reema	Maharani's Science College,Mysore	
22.	Rashmi	Maharani's Science College,Mysore	
23.	Vindu vahini	Maharani's Science College,Mysore	
24.	Dr.Jayasheelan	Maharani's Science College,Mysore	
25.	Kavitha	Maharani's Science College,Mysore	
26.	Bharathi N	SDM college, Mysore	
27.	Dr.Gunasheelan	St Philomenas college Mysore	
28.	Dr.Nagaraj Urs	St Philomenas college Mysore	
29.	Dr.R Manjunatha	Mahajanas college Mysore	
30.	Dr.Poornima	Mahajanas college Mysore	

31.	Dr.Roopa	Govt First grade college Gundlupet	
32.	Dr.Mahadevaprasad T N	GFGC, Gundlupet	
33.	Sophia	Teresian college, Mysore	
34.	Dr.Annie Mathew	Teresian college, Mysore	
35.	Dr.Srinivs P	GFGC, Kollegal	
36.	Lakshmi N M	GFGC, Kollegal	
37.	Sri. S Shreekanth	NIE College, Mysore	
38.	Sri G.Shivakumaraswamy	JSS College ooty road, Mysore	
39.	Umesh V.	JSSCW,Saraswathipuram, Mysore	
40.	Yashwanth D.B.	JSSCW,Saraswathipuram, Mysore	
41.	Meghana R	JSSCW,Saraswathipuram, Mysore	
42.	Chandan N.	GFGC, Chamaraja Nagar	
43.	Manjunath	GFGC, Chamaraja Nagar	
44.	Galabe Satishbabu	GFGC, Mandya	
45.	Krupashree P	Yuvaraja's College	
46.	Girish	Maharani's Science College	
47.	Nanda Kumar	Maharani's Science College	

Chairman, BOE is authorized to approve additional members if required.