BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

(Semester Scheme with Multiple Entry and Exit Options for Under Graduate Course)

Syllabus for Physics
(V & VI Semester)

2023-24

Board of Studies in Physics (UG) Members

Prof. B . Eraiah Chairman		Dept. Physics, Bangalore University, Bengaluru-56
Sri G.Ramesha,	Member	PES College, Hanumanthanagar, Bengaluru-50
Dr. R.S. Muralidhara	Member	PES College, Hanumanthanagar, Bengaluru-50
Dr. P.Aswini	Member	Vijaya College, R.V. Road, Basavanagudi, Bengaluru -04
Dr. K.S.Suresh	Member	Vijaya College, R.V. Road, Basavanagudi, Bengaluru -04
Smt. Manjula S N	Member	SJR College for Women,Rajajinagar,Bengaluru-03
Dr. V .S.Rohini	Member	Nrupathunga University, Nrupathunga Road, Bengaluru-01
Dr. D. Usharani	Member	MES College of Arts, Commerce and Science, Malleswaram,Bengaluru-3
Dr. Mohan Kumar B. V	Member	GFGC, Yalahanka, Bengaluru-64

Date: 23.08.2023
Place: Bengaluru

Proceedings of the BOS Physics (UG) meeting of Bangalore City University, Bangalore, held on 23rd August 2023.

The Chairman welcomed all the BOS members and presented the following agenda for discussion.

Agenda:

(i) To finalize the Panel of Examiners (UG) for the 2023-24

(ii) To approve the BSc Physics Syllabus I & II and V & VI semester (prepared in accordance with the National Education Policy)

After elaborate discussions the members approved

1. Syllabus for I & II and V & VI Semester B.Sc Physics Course (UG) to be implemented from the academic year 2023-24 following NEP guidelines.
2. The UG Panel of examiners has been updated by including teachers from all the affiliated colleges. The BOS unanimously approves the panel of examiners for UG for the academic year 2023-24.

Members of the BOS (UG) Physics

Sl. No	Names	Members	Signature
01	Dr. B. Eraiah, Professor PG Department of Physics, Bangalore University, Bengaluru-560056.	Chairman	
02	Dr. K.S.Suresh Associate Professor Department of Physics, Vijaya College, R.V.Road, Bengaluru-560004.	Member	-Absent —
03	Dr. G.Ramesha, Associate Professor Department of Physics, PES College50 Feet Road, Mysore bank colony, Hanumantha nagar, Bengaluru-560050	Member	
04	Dr. R.S. Muralidhara, Associate Professor, Department of Physics, PES College50 Feet Road, Mysore bank colony, Hanumantha nagar, Bengaluru-560050	Member	- Absent —
05	Dr. Vasu, Associate Professor Department of Physics, Vivekananda degree College, Dr. Rajkumar Road, Rajajinagar II stage, Bangalore-55	Member	- Retired -
06	Dr. P. Ashwini Associate Professor, Department of Physics, Vijaya College, R.V. Road, Basavanagudi,Bangalore-560 004	Member	
07	Smt. Manjula S N Associate Professor, Department of Physics, SJR College For Women, Rajajinagar, Bengaluru-560003.	Member	23/08/2023
08	Dr. V S Rohini Professor, Department of Physics, Nrupathunga University (Govt. Science College) Nrupathunga Road, Bengaluru-560 001 .	Member	23/08/23
09	Dr. D. Usharani Associate Professor, Department of Physics, MES College of Arts, Commerce and Science, Malleswaram, Bangalore	Member	23/08/23
10	Dr. Mohan Kumar B V Associate Professor, Department of Physics, GFGC, Yalahanka, Bangalore-64	Member	

Dr. B. ERAIAH
M.Sc. M.Phil. Ph.D.,
Professor, Department of Physics
Bangalore University, Bangalore-560056

COURSE FRAME WORK IN PHYSICS AS PER HIGHER EDUCATION COUNCIL GUIDELINES (for Two Major)

Sem. No.	Course Category	Course Code	Course Title	Credits Assigned	Instructional Hours per week		Duration of Exam (Hrs.)	Marks		
					Theory	Practical		IA	Exam	Total
V	DSC PHYSICS MAJOR	PHY.DSCT5	Classical Mechanics -I and Quantum Mechanics-I	04	04		2 ½	40	60	100
		PHY.DSCP5	Classical Mechanics -I and Quantum Mechanics-I Practical	02	-	04	04	25	25	50
		PHY.DSCT6	Elements of Atomic, Molecular and Laser Physics	04	04		2 ½	40	60	100
		PHY.DSCP6	Elements of Atomic, Molecular and Laser Physics Practical	02	-	04	04	25	25	50
	DSC SECOND MAJOR	X9-T		04	04		02	40	60	100
		X10-P		02	-	04	03	25	25	50
		X11-T		04	04		02	40	60	100
		X12-P		02	-	04	03	25	25	50
	SEC		Employability skills or Cyber Security	03	02	02		25	25	50
			Total	**27**				**285**	**365**	**650**
VI	DSC PHYSICS MAJOR	PHY.DSCT7	Elements of Condensed Matter & Nuclear Physics	04	04		2 ½	40	60	100
		PHY.DSCP7	Elements of Condensed Matter & Nuclear Physics Practical	02	-	04	04	25	25	50
		PHY.DSCT8	Electronic Instrumentation & Sensors	04	04		2 ½	40	60	100
		PHY.DSCP8	Electronic Instrumentation & Sensors Practical	02	-	04	04	25	25	50
	DSC SECOND MAJOR	X13-T		04	04		02	40	60	100
		X14-P		02	-	04	03	25	25	50
		X15-T		04	04		02	40	60	100
		X16-P		02	-	04	03	25	25	50
	Internship	INTERNSHIP	Internship	02		04		50		50
			Total	**26**				**310**	**340**	**650**

Program Name	BSc in Physics		**Semester**	V
Course Title	**Classical Mechanics and Quantum Mechanics-I (Theory)**			
Course Code	PHY.DSCT5		**No. of Credits**	04
Contact Hours	60 Hours		**Duration of SEA/Exam**	2 ½ Hours
Formative Assessment Marks		40	**Summative Assessment Marks**	60

Course Outcomes (COs):

- Inertial and non-inertial frames of reference.
- Apply the Lorentz transformations to transform velocities in special relativity.
- Calculate the relativistic Doppler effect.
- Limitations of classical physics.
- Physical significance of wave function: expectation values and probability.
- Understanding uncertainty relation.
- Examples of exactly solvable potentials.
- Importance of commutation relations.

Contents	60 Hrs
Unit-1: 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 conservation of 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
Unit-2: Relativity: Newtonian principle of relativity. Non-inertial frames and fictitious forces. Special Theory of Relativity: Michelson-Morley Experiment and its result. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Mass energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. **12 Hours** **Activities: 03 Hours**	15
Unit-3: 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	15

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**	
Unit-4: 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), 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 Occasion/ type	**Marks**
One internal test	20
Assignment and Activities	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	Classical Mechanics , Dr. B.A Kagali,
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	AjoyGhatak, 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.
15	Introduction to Special Theory of Relativity, Robert Resnick, John Wiley and Sons First Edition
16	Special Relativity, A P French, MIT, w.w.Nortan and Company First Ed (1968)

Course Title	**Classical Mechanics and Quantum Mechanics-I (Practical)**	**Practical Credits**	02
Course Code	PHY.DSCP5	**Contact Hours**	04Hours
Formative Assessment	25 Marks	**Summative Assessment**	25 Marks
Practical Content			

Lab experiments: (at least 4 experiments from 1-6 and 4 experiments from 7-16)

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) Determination of acceleration due to gravity using an Atwood's machine.

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

6) Verification of the Principle of Conservation of Linear Momentum

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

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

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

10) To study the I-V characteristics of solar cell.

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

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

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

14) Determination of quantum efficiency of Photodiode.

15) A code in C/C++/Scilab to find the first seven eigen states and eigen functions of Linear Harmonic Oscillator by solving the Schrödinger equation.

16) A code in C/C++/Scilab to plot and analyse the wavefunctions for particle in aninfinite potential well.

17) Measurement of wavelength of sodium D line/wavelength separation of sodium D doublet lines using Michelson Interferometer.

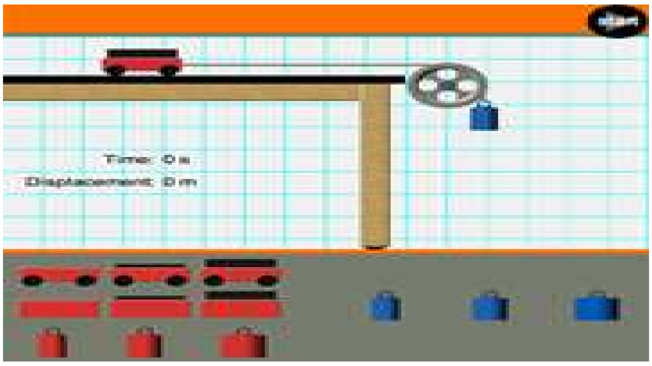
Pedagogy: Demonstration/Experiential Learning / Self Directed Learning etc.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
One internal test	15
Activity	10
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 DrNeetu 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.

Activities

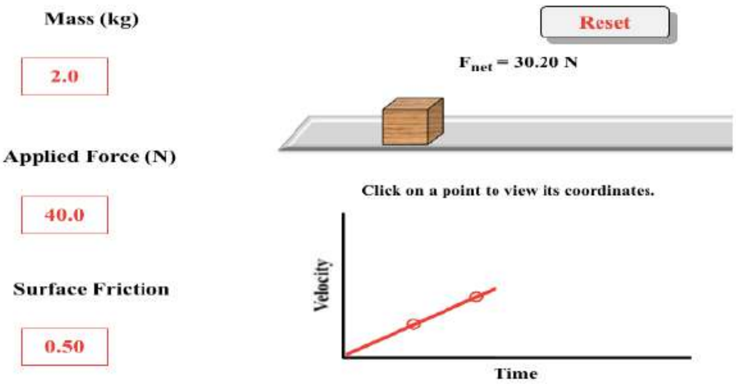
1



Atwood's Machine

Everyone is fascinated by pulleys. In this Interactive, learners will attach two objects together by a string and stretch the string over a pulley. Both an Atwood's machine and a modified Atwood's machine can be created and studies. Change the amount of mass on either object, introduce friction forces, and measure distance and time in order to calculate the acceleration.

Newton's Laws of Motion



Force

When forces are unbalanced, objects accelerate. But what factors affect the amount of acceleration? This Interactive allows learners to investigate a variety of factors that affect the acceleration of a box pushed across a surface, The amount of applied force, the mass, and the friction can be altered. A plot of velocity as a function of time can be used to determine the acceleration.

In the Balloon Car Lesson Plan, students build and explore balloon-powered cars. This lesson focuses mostly on energy, but it also demonstrates Newton's laws of motion.

Guidance is provided for talking specifically about the third law of motion. *Question*: how does the air escaping the balloon relate to Newton's third law of motion? Does the car continue to coast after the balloon is deflated? Why or why not?

Most of the activities and lessons below *focus* on one or two of the laws of motion. The Build a Balloon Car activity specifically **talks about all three of Newton's laws of motion** students can observe when building and experimenting with a simple balloon-powered car. This is an accessible hands-on activity that uses recycled materials and balloons for a fun combined engineering design project and physics experiment. The activity can be used with a wide range of grade levels to introduce and demonstrate the laws of motion. See the "Digging Deeper" section for a straightforward discussion of how each law of motion can be identified in the balloon car activity. (For a related lesson plan, see Balloon Car Lesson Plan, which is NGSS-aligned for middle school and focuses on the third law of motion.)

In the Push Harder — Newton's Second Law , students build their own cars using craft materials and get hands-on exploring Newton's second law of motion and the equation "force equals mass times acceleration" (F=ma). Options for gathering real-time data include using a mobile phone and a sensor app or using a meter stick and a stopwatch. *Questions*: What is the relationship between force, mass, and acceleration? As force increases, what happens to acceleration?

In the Skydive Into Forces , students make parachutes and then investigate how they work to slow down a falling object. As students investigate the forces that are involved, educators can introduce Newton's second law of motion and how different forces change the resulting speed of a falling object. *Questions*: What forces help slow down the speed of a falling object? How does a parachute help slow the fall?

	
2	Both standard cameras (DSLRs, phone cameras) and our scientific cameras work on the principle of photoelectric effect to produce an image from light, involving the use of **photodetectors**and**sensor pixels. Prepare a report on the working of digital camera.**
3	Demonstration of Heisenberg uncertainty principle in the context of diffraction at a single slit: The uncertainty in the momentum Δp_x correspond to the angular spread of principal maxima *Θ*. Then, $\Delta p_x = \sin\theta . p$ where *p* is the momentum of the incident photon. Conduct the diffraction at a slit experiment virtually using the following link *https://www.walter-fendt.de/html5/phen/singleslit_en.htm* **1.** Measure the angular spread (*Θ*) for different slit widths (Δx) for given wavelength of the incident photon. **2.** Determine the momentum of the incident photon using $$p = \frac{h}{\lambda}$$ **3.** Create a line of best fit through the points in the plot $\frac{1}{\Delta p_x}$ against $\Delta x$and find its slope. How this exercise is related to Heisenberg Uncertainty principle. Make a report of the observations.
4	Virtual lab to demonstrate Photoelectric effect using *Value@Amritha*:Conduct the virtual experiment using the following link *https://vlab.amrita.edu/?sub=1&brch=195&sim=840&cnt=1* 1. Determine the minimum frequency required to have Photoelectric effectfor an EM radiation, when incident on a zinc metal surface. 2. Determine the target material if the threshold frequency of EM radiation is$5.5 x 10^{15}$ Hz in a particular photoelectric experimental set up. 3. Determine the maximum kinetic energy of photo-electrons emitted from a Zinc metal surface, if the incident frequency is $3x10^{15}$Hz. **4.** What should be the stopping potential for photoelectrons if the target Material used is Platinum and incident frequency is $2x10^{15}$Hz? Make a report of the calculations.
5	Visualization of wave packets using Physlet@Quantum Physics: The concept of group velocity and phase velocity of a wave packet can be studied using thislinkhttps://www.compadre.org/PQP/quantum-need/section5_9.cfm Students can take up the exercises using the link which is as followshttps://www.compadre.org/PQP/quantum-need/prob5_11.cfm Six different classical wave packets are shown in the animations. Which of the wave packets have a phase velocity that is: greater than / less than / equal to the group velocity? Make a report of the observations.
6	Superposition of eigen states in an infinite one - dimensional potential well using QuVis (Quantum Mechanics Visualization Project): Construct different possible states by considering the first three eigen states and study the

	variation of probability density with position. Take the challenges after understanding the simulation and submit the report. The link is as follows https://www.standrews.ac.uk/physics/quvis/simulations_html5/sims/SuperpositionStates/SuperpositionStates.html
7	Determination of expectation values of position, momentum for a particle in a an infinite one - dimensional potential well using Physlet@Quantum Physics: The link to the visualization tool for the calculation is as follows https://www.compadre.org/PQP/quantum-theory/prob10_3.cfm A particle is in a one-dimensional box of length $L = 1$. The states shown are normalized. The results of the integrals that give $<x>$ and $<x^2>$ and $<p>$ and $<p^2>$. You may vary n from 1 to 10. a) What do you notice about the values of $<x>$ and $<x^2>$ as you vary n? b) What do you think $<x^2>$ should become in the limit of $n \rightarrow \infty$? Why? c) What do you notice about the values of $<p>$ and $<p^2>$ as you vary n? Make a report of the calculations.
8	Determination of expectation values for a particle in a one-dimensional harmonic oscillator using Physlet@Quantum Physics: The link to the visualization tool for the calculation is as follows https://www.compadre.org/PQP/quantum-theory/prob12_2.cfm A particle is in a one-dimensional harmonic oscillator potential ($\hbar = 2m = 1$; $\omega = k = 2$). The states shown are normalized. Shown are ψ and the results of the integrals that give $<x>$ and $<x^2>$ and $<p>$ and $<p^2>$. Vary n from 1 to 10. a) What do you notice about how $<x>$ and $<x^2>$ and $<p>$ and $<p^2>$ change? b) Calculate $\Delta x . \Delta p$ for $n = 0$. What do you notice considering $\hbar = 1$? c) What is E_n? How does this agree with or disagree with the standard case for the harmonic oscillator? d) How much average kinetic and potential energies are in an arbitrary energy state? Make a report of the calculations.
9	Calculate uncertainties of position and momentum for a particle in a boxusingPhyslet@Quantum Physics: The link to the visualization tool for the calculation is as follows https://www.compadre.org/PQP/quantum-theory/prob6_3.cfm A particle is in a one-dimensional box of length $L = 1$. The states shown are normalized. The results of the integrals that give $<x>$ and $<x^2>$, and $<p>$and $<p^2>$. You may vary n from 1 to 10. a. For $n = 1$, what are Δx and Δp? b. For $n = 10$, what are Δx and Δp?
10	Write expressions for the three wave functions using Physlet@QuantumPhysics:The link to the visualization tool for the calculation is as follows https://www.compadre.org/PQP/quantum-theory/prob8_1.cfm These animations show the real (blue) and imaginary (pink) parts of three time-dependent energy eigenfunctions. Assume x is measured in cm and time is measured in seconds. a. Write an expression for each of the three time-dependent energy eigenfunctions in the form: $e^{i(kx-wt)}$. b. What is the mass of the particle? c. What would the mass of the particle be if time was being shown in ms? Make a report of the calculations.
11	If you store a file on your computer today, you probably store it on a solid-state drive (SSD), Make a detailed report on the role of quantum tunnelling in these devices.

Program Name	BSc in Physics		**Semester**	V
Course Title	**Elements of Atomic, Molecular& Laser Physics (Theory)**			
Course Code	PHY.DSCT6		**No. of Credits**	04
Contact Hours	60 Hours		**Duration of SEA/Exam**	02 ½ Hours
Formative Assessment Marks		40	**Summative Assessment Marks**	60

Course Outcomes (COs): • Description of atomic properties using basic atomic models. • Interpretation of atomic spectra of elements using vector atom model. • Interpretation of molecular spectra of compounds using basics of molecular physics. • Explanation of laser systems and their applications in various fields.	
Contents	**60 Hours**
Unit-1: 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
Unit-2: Vector atomic model and optical spectra Vector atom model – spatial quantisation, spinning electron; Quantum numbers associated with vector atomic model; Coupling schemes – L-S and j-j coupling; 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; Optical spectra – spectral terms, spectral notations, selection rules, intensity rules;Larmor frequency, Fine structure of the sodium D-line; Zeeman effect:	15

Types, Experimental study and classical theory of normal Zeeman effect, Zeeman shift expression (no derivation), examples; Stark effect: Experimental study, Types and examples. **12 Hours** **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.	
Unit-3: 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 – Experimental study of Raman effect, Stoke's and anti-Stoke's lines, classical and quantum approaches,; 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
Unit-4: 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	15

specific application, and draw the inferences. Students also make the presentation of the study.	

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**
One internal test	20
Assignment /Activities	20
Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	Modern Physics, R. Murugeshan, KiruthigaSivaprakash, Revised Edition, 2009, S. Chand & Company Ltd.
2	Atomic & Molecular spectra: Laser, Raj Kumar, Revised Edition, 2008, KedarNath 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.DSCP6	**Contact Hours**	04 Hours
Formative Assessment	25 Marks	**Summative Assessment**	25 Marks

Practical Content

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 value of e/m by Magnetic focusing or Bar magnet.
8. To determine the ionization potential of mercury.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To determine the absorption lines in the rotational spectrum of Iodine vapour.
11. To determine the force constant and vibrational constant for the iodine molecule from its absorption spectrum.
12. To determine the wavelength of laser using diffraction by single slit/double slits.
13. To determine wavelength of He-Ne laser using plane diffraction grating.
14. To determine angular spread of He-Ne laser using plane diffraction grating.
15. Study of Raman scattering by CCl_4 using laser and spectrometer/CDS.
16. Study of rotational vibrational spectrum HBr molecule
17. Study of Raman spectra of Nitrogen

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

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

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
One internal test	15
Activity	10
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.
5	Experiments in General Physics, Dr. Rohini V S, 2019, Taranga publications

Program Name	BSc in Physics	**Semester**	VI
Course Title	**Elements of Condensed Matter & Nuclear Physics (Theory)**		
Course Code	PHY.DSCT 7	**No. of Credits**	4
Contact Hours	60Hours	**Duration of SEA/Exam**	2 ½ Hours
Formative Assessment Marks	40	**Summative Assessment Marks**	60

4

Course Outcomes (Cos):

- Elemental Crystallography.
- Knowledge about X-rays and Diffraction of X-rays.
- Discussion of Classical and Quantum free electron theory including their limitations.
- Explanation the basic properties of nucleus.
- Understanding the concepts of binding energy and binding energy per nucleon v/s mass number graph.
- Explanation of alpha, beta and gamma decays.
- Study of interaction of gamma radiation with matter by photoelectric effect, Compton scattering and pair production.
- Study of different nuclear detectors such as ionization chamber, Geiger-Mueller counter, Scintillation detectors, photo-multiplier tube and semiconductor detectors.
-

Contents	60 Hours
Unit-1: Crystal systems and X-rays: Crystal structure**:** SpaceLattice, 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 for cubic crystal. **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	15

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**	
Unit-2: 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; 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**	15
Unit3: 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
Unit4: 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**
One internal test	20
Assignment / Activities	20
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,Pragatiprakashan Meerut(2017). 3. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008). 4. Nuclear Physics, Irving Kaplan, Narosa Publishing House 1. IntroductiontosolidStatePhysics,***CharlesKittel***, VIIedition, (**1996**) 5. Solid State Physics-**A Jdekker**, MacMillanIndiaLtd, (**2000**) 6. Essentialofcrystallography,**MAWahab**, NarosaPublications(**2009)** 7. Solid State Physics-**SO 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.DSCP7	Contact Hours	04Hours
Formative Assessment	25 Marks	Summative Assessment	25 Marks

Practical Content

CONDENSED MATTER PHYSICS

1. Determination of lattice constant using X-ray powder photograph (FCC)
2. Hall Effect in semiconductor: determination of mobility, hall coefficient.
3. Energy gap of semiconductor (diode/transistor) by reverse saturation method
4. Thermistor energy gap
5. Fermi Energy of Copper
6. Analysis of X-ray diffraction spectra and calculation of lattice parameter.(BCC)
7. Particle size determination of lycopodium powder using laser diffraction.
8. Specific Heat of Solid by Electrical Method
9. Determination of Dielectric Constant of polar liquid.
10. Determination of dipole moment of organic liquid
11. B-H Curve Using CRO.
12. Spectral Response of Photo Diode and its I-V Characteristics.
13. Determination of particle size from XRD pattern using Debye-Scherrer formula.
14. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
15. Measurement of susceptibility of paramagnetic solid (Gouy's Method)

NUCLEAR PHYSICS

1. Study the characteristics of Geiger-Mùller Tube. Determine the threshold voltage, plateau region and operating voltage.
2. Study the absorption of beta particles in aluminium foils using GM counter. Determine mass attenuation coefficient of Aluminium foils.
3. Study the absorption of beta particles in thin copper foils using G M counter and determine mass attenuation coefficient.
4. 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.
5. Determine the end point energy of Tl-204 source by studying the absorption of beta particles in aluminium foils.
6. 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 Occasion/ type	**Marks**
One internal test	15
Activity	10
Total	**25 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	IGNOU: Practical PhysicsManual
2	Saraf : ExperimentinPhysics, VikasPublications
3	S.P. Singh : Advanced Practical Physics
4	Melissons : Experiments inModernPhysics
5	Misra and Misra, PhysicsLab.Manual, South Asianpublishers, (**2000**)
6	Gupta and Kumar, Practical physics, Pragatiprakashan,(**1976**)
7	Experiments in General Physics, Dr. Rohini V S, 2019, Taranga publications

Program Name	BSc in Physics		**Semester**	VI
Course Title	**Electronic Instrumentation & Sensors (Theory)**			
Course Code:	PHY.DSCT8		**No. of Credits**	04
Contact Hours	60 Hours		**Duration of SEA/Exam**	2 ½ 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 usageof 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**
Unit-1: Power supply AC power and its characteristics, Single phase and three phase, Need for DC power supply and its characteristics, line voltage and frequency, Half wave and Full wave (Bridge) Rectifier, ripple factor,LC Filters: T-section and π-section filters, electronic voltage regulators using ICs.	15

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** 1. 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. 2. Extend the range of measurement of voltage of a voltmeter (analog or digital) using external component and circuitry. Design your own circuit and report. 3. 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. 4. 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.	
Unit-2: Wave form generators and Filters Basic principle of standard AF signal generator: Types wave forms. Fixed frequency and variable frequency, AF sine wave generator: Phase shift and Wein-bridge oscillators using op-amp-principle and working.Square and triangular wave generator using op-amp. 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
Unit-3: 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).	15

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.	
Unit-4: 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. 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° 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.	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 Occasion/ type	**Marks**
One internal test	20
Assignment / Activities	20
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)

References
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.DSCP8	**Contact Hours**	04Hours
Formative Assessment	25 Marks	**Summative Assessment**	25 Marks

Practical Content

List of experiments (At least 8 experiments to be performed)

1. Construct a DC power supply using a bridge rectifier and a capacitor filter. Use a Zener diode or a 3-pin voltage regulator and study the load and line regulation characteristics. Measure ripple factor with and without filter and compare with theoretical values.
2. Calibration of a low range voltmeter using a potentiometer
3. Calibration of an ammeter using a potentiometer
4. Design and construct a Wien bridge oscillator (sine wave oscillator) using μA 741 op-amp. Choose the values of R and C for a sine wave frequency of 1 KHz. Vary the value of R and C to change the oscillation frequency.
5. Design and construct a square wave generator using μA 741 op-amp. Determine its frequency and compare with the theoretical value. Also measure the slew rate of the op-amp. If the 741 is replace by LM318, study how does the waveform compare with the previous one.
6. Study the frequency response of a first order op-amp low pass filter
7. Study the frequency response of a first order op-amp high pass filter
8. Study the characteristics of *pn*-junction of a solar cell and determine its efficiency.
9. Study the illumination intensity of a solar cell using a standard photo detector (e.g., lux meter).
10. Study the characteristics of a LED (variation of intensity of emitted light).
11. Design and construct phase shift oscillator using op-amp
12. Study the characteristics of a photo-diode
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/ Experiential Learning / Self Directed Learning etc.

Formative Assessment for Practical

Assessment Occasion/ type	Marks
One internal test	15
Activity	10

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
4. Experiments in General Physics, Dr. Rohini V S, 2019, Taranga publications

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.

BSc Physics 5th SEM–NEP Syllabus (2023-24)

Course code: PHY.DSCT5

Classical Mechanics-I and Quantum Mechanics-I

Unit-1: (12 Hours)

- **Introduction to Newtonian Mechanics (4 hours)**
- **Lagrangian Formulation (8 hours)**

Unit-1: Chapter-1:

Introduction to Newtonian Mechanics (Prescribed syllabus)

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, work done by a force, conservative force and conservation of energy.

Unit-1: Chapter-1:

Introduction to Newtonian Mechanics (Blow-up syllabus)

Frames of references -Inertial & Non-inertial frames of reference –Differences & examples,

Newton's laws of motion-Position, Velocity, Acceleration, Momentum of a particle, dot notation for defining derivatives, Newton's Laws of motion.

Mechanics of a particle-Linear Motion**-Conservation of Linear Momentum-**Statement, explanation with examples. Angular motion- angular Velocity ω, angular momentum $\vec{L} = \vec{r} \times \vec{p}$ or $\vec{L} = mr^2\omega$.

Torque - $\vec{\tau} = \vec{r} \times \vec{F}$, Newton's II law, angular momentum and torque $\frac{d\vec{L}}{dt} = \vec{\tau}$

Conservation of angular Momentum -Statement, explanation with examples

Work done by a force- Work and Kinetic Energy, $W_{12} = K_2 - K_1$

Conservative force- Conservative Force, Potential Energy as a function of Position, $F = -grad\, V$

Conservation of energy - Statement, Explanation with illustrations.

Unit-1: Chapter-2: Lagrangian Formulation

(Prescribed syllabus)

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.

Unit-1: Chapter-1: Lagrangian Formulation

(Blow-up syllabus)

Basics of Lagrangian mechanics- Co-ordinate systems- Cartesian & Polar co-ordinates, **degrees of freedom, constraints, Holonomic constraints, non-holonomic constraints, Scleronomic and Rheonomic constraints.**

Generalized coordinates - Transformation equations

$\vec{r_i} = \vec{r_i}\,(q_1, q_2, q_3 \ldots \ldots q_j)$, Illustrations- Motion of a simple pendulum,

Generalized velocity $\dot{q} = \frac{dq}{dt}$, Virtual displacement**, virtual work, Principle of virtual work.**

Lagrangian function $L = T - V$, D'Alembert's principle -Statement, explanation, arrive at $\sum(F_i - \dot{p_i}) \cdot \partial r_i = 0$, **Lagrange equations -** Lagrange's equation of motion in general form and for conservative system $\frac{d}{dt}\frac{\partial T}{\partial \dot{q_i}} - \frac{\partial T}{\partial q_i} = 0$ (without derivation)

Importance of Lagrangian Formulation, Procedure for formation of Lagrange's equations

Newton's equation of motion from Lagrange equations - Derivation of $F = \frac{dP}{dt}$

Simple pendulum - Equation of motion of a simple pendulum $\ddot{\theta} + \frac{g}{l}\sin\theta = 0$ using Lagrangian method, deduce the formula for Time period of oscillations

Atwood's machine -Equation of motion of a system of two masses connected by a string passing over a pulley $\ddot{x} = a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$ **and**

Linear harmonic oscillator - Equation of motion of a linear harmonic oscillator $mx + \dot{K}x = 0$

Unit-2: Relativity
(Prescribed syllabus)
Newtonian principle of relativity. Non-inertial frames and fictitious forces.

Special Theory of Relativity: Michelson-Morley Experiment and its result.

Postulates of Special Theory of Relativity. Lorentz Transformations.

Simultaneity and order of events.

Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Mass energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Unit-2: Relativity
(Blow-up syllabus)

Newtonian principle of relativity -Rest & Motion – relative, Gallian transformation & its limitations **Non-inertial frames and fictitious forces. Michelson-Morley Experiment** -Principle. Description, Theory **and its result. Postulates of Special Theory of Relativity. Lorentz Transformations** - Derivation. **Simultaneity and order of events. Lorentz contraction**-Proper length, Derivation of L= $L_0\sqrt{1-\frac{v^2}{c^2}}$. **Time dilation** -Proper time, Derivation of t= $\frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$, time dilation effect for μ-mesons , twin paradox.

Relativistic transformation of velocity, frequency and wave number - Relativistic addition of velocities -Velocity addition theorem **Variation of mass with velocity**-Derivation of $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$, Rest mass. **Mass energy Equivalence**- Derivation of $E = mc^2$, Experimental evidences. **Relativistic Doppler effect** - $\lambda_{Obs} = \lambda_S \sqrt{\frac{1+\frac{V}{c}}{1-\frac{V}{c}}}$ (without Derivation), Longitudinal & Transverse Doppler effect,

Relativistic Kinematics. Transformation of Energy and Momentum -Arriving at momentum - energy relation $E = c\sqrt{P^2 + m_0^2\, c^2}$

Program Name: BSc in Physics, Semester V (NEP), BCU

Course title: Classical Mechanics and Quantum Mechanics-I (Theory)

Course Code: PHY.DSCT5

Contact Hours: 60 Hours   No. of Credits: 04

Unit-3: 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

BLOW-UP

Text in black is the syllabus prescribed and text in red is the blow-up

- Introduction to quantum mechanics: Distinction between classical and quantum mechanics, quantum theory of radiation
- Brief discussion on failure of classical physics to explain black body radiation: Black body spectrum, Ultraviolet catastrophe, quantum theory: Planck's law of radiation (without derivation), deducing Wien's law and Rayleigh –Jeans law from Planck's law.
- Photoelectric effect: Experiment and results, Discussion on failure of classical physics to explain PE effect, Einstein's theory and equation.
- Spectra of atoms: Origin of Line spectra of atoms, equation for wave number
- Stability of atoms: accelerating electron loses energy, hence should collapse into the nucleus, on the contrary atoms are mostly found to be stable.

- Compton effect: Brief discussion on failure of classical physics- Classical views and experimental observations
- Compton scattering: Expression for Compton shift (With derivation)

  Problems (4 Hrs)
- Matter waves: de Broglie hypothesis of matter waves, explanation of matter waves

  Arriving at $\lambda = \frac{h}{p}$, different forms of the equation

  Electron microscope (Qualitative)

  What is an Electron Microscope?

  Working Principle of Electron microscope (7-8 points)

  Mention of Types of Electron microscope: TEM AND SEM

  Wave description of particles by wave packets- concept of wave packet, Group and Phase velocities: Definitions and equations, and relation between them: Arrive at $v_g = v_p - \lambda \frac{dv_p}{dv_\lambda}$, concept of dispersive medium

  Experimental evidence for matter waves: Davisson- Germer experiment

  G.P Thomson's experiment and its significance.

  Problems (4 Hrs)

- Heisenberg uncertainty principle: [Elementary proof of Heisenberg's relation] Qualitative explanation of principle

  Relation between momentum and position, energy and time, angular momentum and angular position: Mention of the relations between momentum and position, energy and time, angular momentum and angular position

- Illustration of uncertainty principle by Gamma ray microscope thought experiment: Qualitative and quantitative-arriving at equations for $\Delta x \; and \; \Delta p_x$ and uncertainty principle

  Consequences of the uncertainty relations:

  A) Diffraction of electrons at a single slit (quantitative)

  B) Why electron cannot exist in nucleus? (quantitative)

- Two-slit experiment with photons and electrons. Linear superposition principle as a consequence: diagram, analogy to Young's DS experiment and principle of superposition (qualitative).

  Problems (4 Hrs)

Program Name: BSc in Physics, Semester V (NEP), BCU

Course title: Classical Mechanics and Quantum Mechanics-I (Theory)

Course Code: PHY.DSCT5

Contact Hours: 60 Hours No. of Credits: 04

Unit-4: 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), 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

Text in black is the syllabus prescribed and text in red is the blow-up

BLOW-UP

- Probabilistic interpretation of the wave function: Max Born's interpretation, probability density and probability of finding a particle at a given space coordinate, at a given instant of time, contains information about the physical system.
- normalization and orthogonality of wave functions: Definitions, mathematical forms
- Admissibility conditions on a wave function: Mention of characteristics of 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 – operators in quantum mechanics (3 Hrs)
- The probability current: Definition, equation of continuity and its physical significance:

a) Mention of continuity equation in $\vec{J}$ and ρ $\vec{\nabla}.\vec{J} + \frac{\partial \rho}{\partial t} = 0$

b) Writing $\vec{J}$ and ρ in terms of wavefunctions

Mention of physical significance: probability as flowing like a liquid (flux) obeying the continuity equation.

- Postulates of Quantum mechanics: 4 postulates as statements (with necessary mathematical forms), permissible states as normalized wave functions.
- Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples): Definitions of conjugate, Hermitian conjugate and Hermitian operator

Expectation values of operators and their time evolution. Ehrenfest theorem (no derivation): Definition of expectation value of a physical variable, Ehrenfest theorem statement: Expectation values of quantum mechanical operators obey the laws of classical mechanics. Mention of one example: In classical mechanics linear momentum $\vec{p} = m\vec{v}$

According to Ehrenfest theorem: $\langle p_x \rangle = m\frac{d\langle x \rangle}{dt}$

- Particle in a one-dimensional infinite potential well (derivation), degeneracy in three-dimensional case: setting up of SWE, arriving at energy eigen values, normalization condition and the form of eigen functions, graphical representations for ψ and $|\psi|^2$

Problems (5 Hrs)

Particle in a finite potential well (qualitative): Square well potential diagram, mention of potential, mention of energy quantization and

- Transmission across a potential barrier, the tunnel effect (qualitative)

Discuss two cases: i) E< v_o ii) E> v_o

Energy of the particle and v_o is the height of the barrier

diagrammatic representation of tunnelling

- Scanning tunnelling microscope: Principle, applications: It can be used to image topography, measure surface properties, manipulate surface structures, and to initiate surface reactions.
- One-dimensional simple harmonic oscillator (qualitative) - concept of zero - point energy: Setting up of SWE, arriving at energy eigen values and mention of the form of eigen functions

Problems (4 Hrs)

Program Name: BSc in Physics, Semester V (NEP)

PHYSICS C11 – T

Course title: Elements of Atomic, Molecular and Laser Physics

Course Code: PHY.DSCT6

Contact Hours: 60 Hours

No. of Credits: 04

BLOW UP

Unit 1: Basic Atomic models

Thomson's atomic model: Introduction (Why and How atomic model developed) – Atomic spectra, Spectral lines, Rydberg constant., Explanation Thomson's atomic model. Rutherford atomic model – Theory of α-particle scattering (description),Rutherford scattering formula – Qualitative Description. Bohr atomic model – Explanation of Bohr postulates - Derivation of the expression of radius of orbit - The total energy of electron in n[th] orbit ($E_n = \frac{-1}{n^2}\frac{me^4}{8\varepsilon_o^2 h^2}$, $E_n = \frac{-1}{n^2}(13.6ev)$) – Energy levels – Energy states – Energy level diagram, Merits and Limitations of Bohr's theory. 4 Hrs

Origin of the spectral lines – Definition, Classes of Spectra – Emission spectral line and Absorption spectral lines, Emission spectra – Continuous and discontinuous spectra (Line and Band spectra). Spectral series of Hydrogen atom – Explanation of six series observed in the spectrum of Hydrogen atom – Energy level diagram of Hydrogen atom emission spectrum. Effect of nuclear motion on atomic spectra – Derivation $E_n = \frac{-2\pi^2 m^I e^4 z^2}{n^2 h^2}\frac{1}{(4\pi\varepsilon_o)^2}$, $\bar{\nu} = \frac{2\pi^2 m^I e^4 z^2}{n^2 h^2}(\frac{1}{n_1^2} - \frac{1}{n_2^2})$, R = $\frac{2\pi^2 m^I e^4}{ch^3}\frac{1}{(4\pi\varepsilon_o)^2}$. Where $m^I = \frac{mM}{m+M}$, reduced mass of the electron. Ritz Combination Principle and Correspondance principle – Statement and Explanation of Principle. 4 Hrs

Critical potentials – Definition of critical potentials - Significance of critical potential – Explanation of excitation potential and ionization potential (Experimental setup). Franck and Hertz experiment – Method and observation – Importance of Franck & Hertz experiment. Sommerfeld's atomic model – Introduction and concept of general quantization rule and the idea of elliptic orbits for the electron – Concept of quantization of elliptical orbit – Quantum numbers. Derive the condition for allowed elliptical orbits $E_n = \frac{-Ze^2}{2a(4\pi\varepsilon_o)}$ ($\frac{k}{n} = \frac{b}{a}$), – The total energy of the atom with single electron initselliptical orbit. Relativistic effects – To remove the degeneracy (existence of multiple orbits of same energy), Concept of fine structure, Selection rule. 4 Hrs

Unit-2: Vector atomic model and optical spectra

Vector atom model – spatial quantisation, Explanation with examples spinning electron; Explanation with example Quantum numbers associated with vector atomic model Explanation of $n,\ l,\ s,\ j,\ m_l,\ m_s m_j$; Coupling schemes – L-S and j-j coupling Brief explanation ; Pauli's exclusion principle Statement and explanation, To show that the total number of electrons in a shell = $2n^2$ 4 hours

Magnetic dipole moment due to orbital motion of electron – derivation $\mu_l = \left(\frac{e\hbar}{2m}\right) l = \mu_B l$ Concept of μ_B Bohr magneton Magnetic dipole moment due to spin motion of electron $\mu_s = \left(\frac{e\hbar}{2m}\right)$; Lande g-factor and its calculation for different states; $1 + \frac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)} = g$ To find g for states ${}^2S_{1/2}$ ${}^2P_{1/2}\ etc..$ Stern-Gerlach experiment – Experimental arrangement and Principle Mention of $D_x = \frac{1}{2}\ \frac{\mu}{m}\ \frac{dB}{dx}\ \left(\frac{L}{v}\right)^2$ 3 Hours

Fine structure of spectral lines with examples – Explanation and example - Fine structure of sodium D line; Optical spectra – spectral terms, spectral notations, selection rules, intensity rules Brief explanation with an example Larmor frequency Definition and brief explanation, Expression for larmor frequency Zeeman effect: Types, Experimental study and classical theory of normal Zeeman effect, Zeeman shift expression (no derivation), examples; Mention of Zeeman shift $d\lambda = \pm \left(\frac{\lambda^2}{c}\right)\frac{eB}{4\pi m}$ Stark effect: Experimental study, Types and examples.- 5 hours

Unit-3: Molecular Physics

Types of molecules based on their moment of inertia; Brief explanation of Linear molecules, Symmetric tops, Spherical tops, Asymmetric tops. Types of molecular motions and energies; Explanation of Translational, Rotational, Vibrational and Electronic motions and their energies Born-Oppenheimer approximation; Explanation with examples Origin of molecular spectra Explanation $\nu = \frac{E - E'}{h}$ Nature of molecular spectra; Explanation of the band spectra - 3 hours

Theory of rigid rotator Theory of pure rotational spectrum– energy levels and spectrum, To arrive at $E_J = \frac{L^2}{2I}$ and $E_J = \frac{\hbar^2}{2I} J(J+1)$ Energy level diagram Qualitative discussion on Nonrigid rotator and centrifugal distortion; Brief explanation, Vibration – Rotation spectra Theory of vibrating molecule as a simple harmonic oscillator – energy levels and spectrum; Vibrational spectrum To arrive at $E_V = \left(v + \frac{1}{2}\right) \hbar \sqrt{\frac{k}{\mu}}$, Energy level diagram, - 5 hours

Electronic spectra of molecules –Explanation with energy level diagram fluorescence and phosphorescence; Explanation with examples, Energy level diagrams, Comparison between Coherent and incoherent scatterings with examples Raman effect– Experimental study of Raman effect, Stoke's and anti Stoke's lines, Features of Raman lines classical and quantum approaches, Explanation based on polarizability of molecules Quantum theory of Raman effect Applications of Raman effect. - 4 hours

Unit-4: Laser Physics

Ordinary light versus laser light; Characteristics of laser light; Interaction of radiation (visible) with matter Induced absorption, spontaneous emission and stimulated emission with mention of rate equations; Differences between spontaneous and stimulated emissions Einstein's A and B coefficients – Derivation of relation between Einstein's coefficients and radiation energy density; $\rho(\nu) = \frac{A_{21}}{B_{21}}\left[\frac{1}{(e^{(h\nu/kT)}-1)}\right]$ Discussion of Different cases and the condition for laser action - 5 hours

Possibility of amplification of light; Population inversion; Methods of pumping; Metastable states; Requisites of laser – energy source, active medium and laser cavity; Components of laser, Principle of laser, Laser action Difference between Three level and four level lasers with examples; properties of laser - 3 hours

Types of lasers with examples; Mention of different types of lasers Construction and Working principle of Ruby Laser and He-Ne Laser; Energy level diagram, Differences between Ruby laser and He-Ne laser Application of lasers (qualitative) in science & research, isotope separation, communication, fusion, medicine, industry, war and space. - 5 hours