Bangalore University
Department of Physics

Jnanabharathi Campus
Bengaluru – 560 056

Syllabusfor

5rd& 6th Semester B. Sc. Physics

Under-Graduate (UG) Program Framed according to the National Education Policy (NEP 2020)

(Effective from the Academic Year 2023-24)

Board of Studies in Physics (UG) Members

Prof. M. K. Kokila, Dept. of Physics, Bangalore University, Bengaluru-56. (Chairperson)

Sri. Balakrishna M T	**The Rural College, Kanakapura-562 117**
Dr. Ramesh T	**GFGC, Channapatna, Ramanagara.**
Dr.Venkateshappa	**GFGC, Vijayanagar, Bengaluru-40**
Prof.Wajeeha Sultana	**Maharani Cluster University,Bengaluru-1**
Dr.Madhavi K.Y	**GFGC, Channapatna.**
Smt.SeetaVasudevrao	**GFGC, Kengeri, Bengaluru-60**
Dr. Manjunath H C	**GFGC, Devanhalli.**

Board of Studies Members as Invitees

Prof. Ramakrishna Damle	**Department of Physics, Bangalore University, Bengaluru.**
Prof. B. Eraiah	**Department of Physics, Bangalore University, Bengaluru.**
Dr.Sarbari Bhattacharya	**Department of Physics, Bangalore University, Bengaluru.**

Date: 24.08.2023
Place: Bengaluru

Department of Physics
Bangalore University, Bangalore-56

Proceedings of the BOS (UG) Physics meetingheld at 10.30 am on 24th August 2023 at the Department of Physics, BUB-56.

The following agenda was discussed: (1) **B. Sc., 5th and 6th** Semester Syllabus of Physics Papers (2) **Panel of Examiners for UG** for the academic year 2023-2024 and **BOE (Proposed)** for the academic year 2023-24. After elaborate discussions and suitable modifications, the members of the BOS approved both the agenda.

Sl. No.	Name & Affiliation of the BOS Member	Signature
1	**Dr. M. K. Kokila, Professor & Chairperson** **Department Physics, Bangalore University, Bengaluru-56**	Kokila M K 24/08/23
2	**Dr. Venkateshappa Y** **Govt. First Grade College, Vijayanagar, Bengaluru-04**	Absent
3.	**SmtSeetaVasudevrao** **Govt. First Grade College, Kengeri, Bengaluru-60**	Absent
4.	**Dr.WajeehaSulthana** **Maharani Science College for Women, Bengaluru-01**	Wajeeha Sulthana
5.	**Sri Ramesh T** **Govt. First Grade College, Channapattana-571 501.**	Ramesh
6.	**Sri. Balakrishna M T** **The Rural College, Kanakapura-562 117**	[illegible]
7.	**Dr Manjunath H C** **Govt. First Grade College, Devanahalli**	Absent
8.	**Dr.Madhavi, K. Y.** **Govt. First Grade College, Channapattana-571 501.**	K Y Madhavi
	Invitees	
9.	**Prof. Ramakrishna Damle** **Dept. Physics, Bangalore University, Bengaluru-56**	R Damle
10.	**Prof. B. Eraiah** **Dept. Physics, Bangalore University, Bengaluru-56**	[illegible]
11.	**Prof.Sarbari Bhattacharya** **Dept. Physics, Bangalore University, Bengaluru-56**	Sarbari Bhattacharya.

B. Sc. COURSE FOR BANGALORE UNIVERSITY 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		2½	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
			Total	**12**				**130**	**170**	**300**
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
			Total	**12**				**130**	**170**	**300**

Program Name	B.Sc. in Physics		**Semester**	V
Course Title	Classical Mechanics andQuantumMechanics-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
Unit1 : 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 (No derivation). Newton's equation of motion from Lagrange equations, Lagrange's equations for simple pendulum, Atwood's machine and linear harmonic oscillator. **12 Hours** **Activities: 03 Hours**	15
Unit 2: Relativity Inertial and Non-inertial frames, fictitious forces, uniformly rotating frames. Special Theory of Relativity: Michelson-Morley Experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz Transformations, Lorentz length contraction, Time dilation, Concept of Simultaneity, Relativistic transformation of velocity, Relativistic addition of velocities, Variation of mass with velocity, Mass energy equivalence, 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	15

of particles by wave packets, Group and Phase velocities and relation between them, Experimental evidence for matter waves: Davisson- Germer experiment, G.P Thomson experiment. Heisenberg uncertainty relation between: momentum and position, energy and time; Illustration of uncertainty principle by Gamma ray microscope- thought experiment, Consequences of the uncertainty relations: Diffraction of electrons at a single slit, can an electron be part of a nucleus? Two-slit experiment with photons and electrons. **12 Hours** **Activities: 03 Hours**	
Unit 4: Formalism of Quantum Mechanics Probabilistic interpretation of the wave function: Admissibility conditions, normalization, Schrödinger equation for a free particle in one, probability current density, equation of continuity, time-dependent and time-independent Schrodinger equations. Particle in a one-dimensional infinite potential well (derivation), particle in a finite potential well (qualitative), Transmission across a potential barrier, the tunnel effect (qualitative), scanning tunneling microscope, one-dimensional simple harmonic oscillator (qualitative) - concept of zero - point energy. Postulates of Quantum mechanics: States and Observables (position, momentum, angular momentum and energy as examples, Expectation value of observables, time evolution, Ehrenfest theorem (using time evolution) **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/Activities	20
Total	**40**
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.
15	Introduction to Special Theory of Relativity, Rober Resnick, John Wiley and Sons First Edition
16	Special Relativity, A P French, MIT, w.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**	04 Hours
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) Determine the acceleration of gravity is to use 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) Determination of electron charge 'e' by Millikan's Oil drop experiment.

9) To study the characteristics of solar cell.

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

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

12) To study the tunneling in Tunnel Diode using I-V characteristics.

13) Determination of quantum efficiency of Photodiode.

14) 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.

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

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

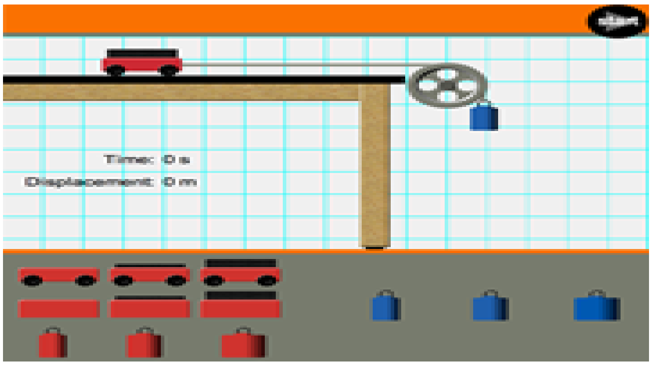
Pedagogy: Demonstration/Experiential Learning / Self Directed Learning etc.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
One Internal Test	15
Activity	10
Total	**25**
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.

Activities (One activity per unit of theory paper is mandatory)

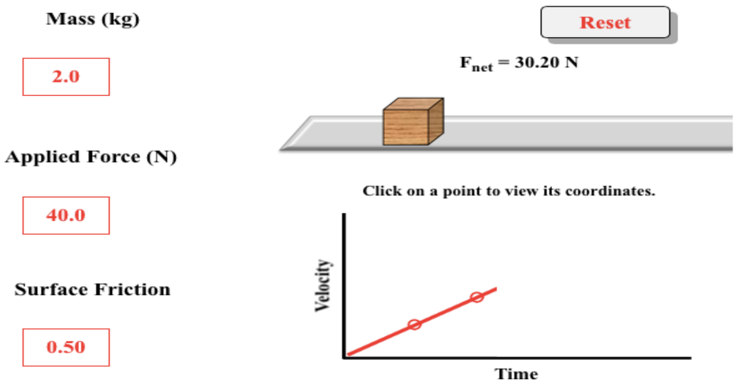
1



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 **photo detectors** 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=h/λ **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$5.5\text{x}10^{15}$ 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 $3\text{x}10^{15}$Hz. **4.** What should be the stopping potential for photoelectrons if the target Material used is Platinum and incident frequency is $2\text{x}10^{15}$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 thislink https://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; ω = 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 boxusing Physlet@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@Quantum Physics: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: $e^{i(kx\text{-}wt)}$. 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	B.Sc. 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**	2 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, Theory of alpha particle scattering, Rutherford scattering formula, Bohr atomic model – postulates, expression for radius, total energy of electron, Sommerfeld's atomic model – model, Derivation of condition for allowed elliptical orbits. Origin of the spectral lines, Spectral series of hydrogen atom,Ritz combination principle, Correspondence principle, excitation potential and ionization potential, Franck-Hertz experiment. Vector atom model – spatial quantization, spin of electron, Quantum numbers associated with vector atomic model. **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 excitation and ionisation potentials of different elements and plot the graph of 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: Atomic spectra L-S and j-j coupling schemes, Pauli's exclusion principle, Magnetic dipole moment due to orbital motion of electron – derivation, Magnetic dipole moment due to spin of an 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),	15

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 to construct vector diagrams for each resultant. Analyze the coupling results and to 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 plotting the graph of dipole moment versus total angular momentum "J". To 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, rigid rotator – energy levels and spectrum, Qualitative discussion on Non-rigid rotator and centrifugal distortion, vibrating molecule as a simple harmonic oscillator – energy levels and spectrum, Electronic spectra of molecules – fluorescence and phosphorescence, Raman scattering, Stokes and anti-Stokes 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 to 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, rate equations, Einstein's A and B coefficients – Derivation of relation between Einstein's coefficients and radiation energy density, amplification of light, Population inversion, Methods of pumping, Metastable states, Components of laser system: energy source, active medium and laser cavity, Types of lasers with examples, Construction and Working principle of Ruby Laser and He-Ne Laser, Application of lasers(qualitative): communication, medicine, industry, defense 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 Occasion/ type	**Marks**
One internal test	20
Assignment/Activity	20
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.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 ionization potential of mercury.
8. To determine the force constant and vibrational constant for the iodine molecule from its absorption spectrum.
9. To determine the wavelength of laser using diffraction by single slit/double slits.
10. To determine wavelength of He-Ne laser using plane diffraction grating.

11. To determine angular spread of He-Ne laser using plane diffraction grating.
12. Absorption bands of $KMnO_4$ using Hartmann's method.
13. Analysis of rotational Raman spectra of N_2 molecule.
14. Analysis of rotational-vibrational spectra of HBr Molecule.

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
One 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.

Program Name	B.Sc. in Physics		**Semester**	VI
Course Title	Elements of Condensed Matter and Nuclear Physics (Theory)			
Course Code	PHY.DSCT7		**No. of Credits**	4
Contact Hours	60 Hours		**Duration of SEA/Exam**	2 ½ Hours
Formative Assessment Marks		40	**Summative Assessment Marks**	60

Course Outcomes (COs):

Course Outcomes of condensed matter physics:

- 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 Hrs**
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 systems, Bravais lattices, Miller Indices, Expression for inter planar spacing. **X Rays**: Production and properties of X rays, Continuous and characteristic X-ray spectra; Moseley's law. **X-Ray diffraction**: Scattering of X-rays, Bragg's law, 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, Weidemann-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 (qualitative). **12 HOURS** **ACTIVITIES: 03 HOURS**	15
Unit 2: Magnetic Properties of Matter, Dielectrics and Superconductivity **Magnetic Properties of Matter** Classification of magnetic materials, Langevin quantum theory of diamagnetism and paramagnetism. Curie's law, Ferromagnetism and magnetic domains (qualitative), anti-ferromagnetism and ferrimagnetism. **Dielectrics**: Electric dipole moment, dielectric susceptibility, dielectric constant, polarizability (electronic, ionic and orientational), calculation of Lorentz field (derivation), Clausius-Mossotti equation (derivation), dielectric loss. Piezo electric effect, cause, examples and applications. **Superconductivity:** Definition, experimental results – Zero resistivity and Critical	15

temperature– The critical magnetic field – Meissner effect, Type I and type II superconductors. **12 Hours** **ACTIVITIES: 3 Hours**	
Unit 3: General Properties of Nuclei: Constituents of nucleus, intrinsic properties of nucleus, quantitative facts about mass, radii, charge density, binding energy, binding energy versus mass number curve. **Radioactivity decay:** Radioactivity: definition of radioactivity, half-life, mean life,Alpha decay: basics of α-decay, Gamow's theory of α emission, Geiger-Nuttall law. β-decay: positron emission, electron capture, neutrino hypothesis. Gamma decay: Selection rules, internal conversion process. **12 Hours** **ACTIVITIES: 03 Hours**	15
Unit 4: Interaction of Nuclear Radiation with matter: interaction of Gamma rays with matter, Compton scattering, photoelectric effect, pair production, Energy loss due to ionization (quantitative description of Bethe-Bloch formula). **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. **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 law 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/Activity	20
Total	**40**
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. Introductiontosolid StatePhysics,***CharlesKittel***, VIIedition, (**1996**) 5. Solid State Physics-**A JDekker**, MacMillanIndia Ltd, (**2000**) 6. Essentialof crystallography,**MA Wahab**, 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**	04 Hours
Formative Assessment 25 Marks		**Summative Assessment**	25 Marks

Practical Content

CONDENSED MATTER PHYSICS

1. Hall Effect in semiconductor: determination of mobility, hall coefficient.
2. Energy gap of semiconductor (diode/transistor) by reverse saturation method
3. Thermistor energy gap
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)

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.
7. Simulation of nuclear decay using dice (Monte Carlo simulation)

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

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
One Internal test	15
One Activity	10
Total	**25**
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**)

Program Name	B.Sc. 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 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, color 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	**60 Hours**
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, 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	15

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. Multi range voltmeter and ammeter.* **12 Hours** **ACTIVITIES:** **03 Hours** **Activities** 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.	
Unit 2: Wave form generators and Filters Basic principle of standard AF signal generator: Fixed frequency and variable frequency, AF sine and square wave generator using op amps, 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
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). *Topic for self-study*: *Lock-in amplifier and its application, phase locked loop.* **12 Hours** **ACTIVITIES:** **03 Hours**	15

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^{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 aluminum). 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/Activity	20
Total	**40**
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.DSCT9	**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. 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. Study the characteristics of a thermistor (temperature coefficient of resistance)
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
One Activity	10
Total	**25**
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.