Government of Karnataka
Curriculum Framework for Undergraduate in Colleges and Universities of Karnataka State.

V & VI Semester Model Syllabus
For
BSc. In Physics.

Submitted to

Vice Chairman
Karnataka State Higher Education Council
Bengaluru, Karnataka – 560009

Model Physics Syllabus

Multi-Disciplinary Programme as per UNIVERSITY-2020

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Model

Curriculum

of

BSc in Physics

5th & 6th Semester

Karnataka State Higher Education Council

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	V
Course Title	Classical Mechanics and Quantum Mechanics- I **(Theory)**		
Course Code:	PHY C9-T	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

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

Contents	60 Hrs
Introduction to Newtonian Mechanics: Frames of references, Newton's laws of motion, inertial and non-inertial frames. Mechanics of a particle, Conservation of linear momentum, Angular momentum and torque, conservation of angular momentum, work done by a force, conservative force and conservative energy. **Lagrangian formulation**: Constraints, Holonomic constraints, non-holonomic constraints, Scleronomic and Rheonomic constraints. Generalized coordinates, degrees of freedom, Principle of virtual work, D'Alembert's principle, Lagrange equations. Newton's equation of motion from Lagrange equations, simple pendulum, Atwood's machine and linear harmonic oscillator.	15 Hrs
Variational principle: Hamilton's principle, Deduction of Hamilton's principle, Lagrange's equation of motion from Hamilton's principle, Hamilton's principle for non-holonomic systems. **Hamiltonian Mechanics**: The Hamiltonian of a system, Hamilton's equations of motion, Hamilton's equations from variational principle, Integrals of Hamilton's equations, energy integrals, Canonical Transformations, Poison Brackets, fundamental properties and equations of motion in Poison Brackets	15 Hrs
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.	
Foundation of Quantum Mechanics Probabilistic interpretation of the wave function - normalization and orthogonality of wave functions, Admissibility conditions on a wave function, Schrödinger equation: equation of motion of matter waves - Schrodinger wave equation for a free particle in one and three-dimension, time-dependent and time-independent wave equations, Probability current density, equation of continuity and its physical significance, Postulates of Quantum mechanics: States as normalized wavefunctions. Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples). Expectation values of operators and their time evolution. Ehrenfest theorem (no derivation), Commutator brackets- Simultaneous Eigen functions, Commutator bracket using position, momentum and angular momentum operators. Particle in a one-dimensional infinite potential well (derivation), degeneracy in three-dimensional case, particle in a finite potential well (qualitative), Transmission across a potential barrier, the tunnel effect (qualitative), scanning tunnelling microscope, One-dimensional simple harmonic oscillator (qualitative) - concept of zero - point energy.	

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

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

References	
1	Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.

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

Course Title	Classical Mechanics and Quantum Mechanics- I Lab **(Practical)**	Practical Credits	**02**
Course Code	PHY C10-P	Contact Hours	**4 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) 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 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 an infinite potential well.

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

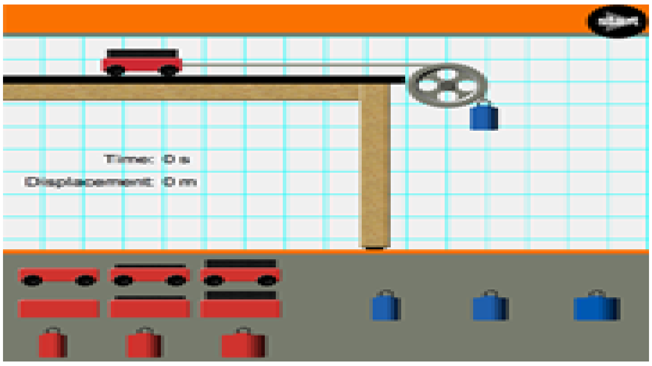
Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Total	**25 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	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

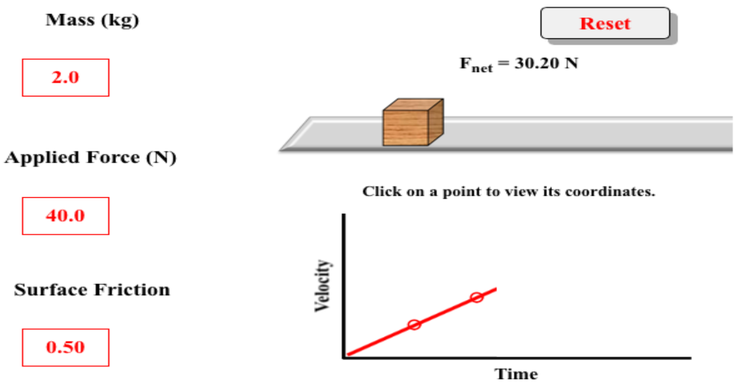
1



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 Δx 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 effect for an EM radiation, when incident on a zinc metal surface. 2. Determine the target material if the threshold frequency of EM radiation is 5.5×10^{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 3×10^{15}Hz. **4.** What should be the stopping potential for photoelectrons if the target Material used is Platinum and incident frequency is 2×10^{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 this link https://www.compadre.org/PQP/quantum-need/section5_9.cfm Students can take up the exercises using the link which is as follows https://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 box using 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: $e^{i(kx-wt)}$.

	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.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Elements of Atomic, Molecular & Laser Physics **(Theory)**		
Course Code:	PHY C11-T	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite (s): PUC Science Knowledge	
Course Outcomes (COs): After the completion of the course, the student will be able to • Describe atomic properties using basic atomic models. • Interpret atomic spectra of elements using vector atom model. • Interpret molecular spectra of compounds using basics of molecular physics. • Explain laser systems and their applications in various fields.	
Contents	**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;	**15**

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'. Analyse 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. Analyse the nature of the graph and draw the inferences.	
Unit 2: Vector atomic model and optical spectra Vector atom model – model fundamentals, spatial quantisation, spinning electron; Quantum numbers associated with vector atomic model; Coupling schemes – L-S and j-j schemes; Pauli's exclusion principle; Magnetic dipole moment due to orbital motion of electron – derivation; Magnetic dipole moment due to spin motion of electron; Lande g-factor and its calculation for different states; Stern-Gerlach experiment – Experimental arrangement and Principle; Fine structure of spectral lines with examples; Spin-orbit coupling/Spin-Orbit Interaction – qualitative; Optical spectra – spectral terms, spectral notations, selection rules, intensity rules; Fine structure of the sodium D-line; Zeeman effect: Types, Experimental study and classical theory of normal Zeeman effect, Zeeman shift expression (no derivation), examples; Stark 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. Analyse 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'. Analyse the nature of the graph and draw the inferences.	**15**
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-	**15**

rigid rotator and centrifugal distortion; Theory of vibrating molecule as a simple harmonic oscillator – energy levels and spectrum; Electronic spectra of molecules – fluorescence and phosphorescence; Raman effect – Stoke's and anti-Stoke's lines, characteristics of Raman spectra, classical and quantum approaches, Experimental study of Raman effect; Applications of Raman effect. **12 Hours** **Activities:** **03 Hours** 1. Students to estimate energy of rigid diatomic molecules CO, HCl and plot the graph of rotational energy versus rotational quantum number 'J'. Analyse the nature of the graph and draw the inferences. Also students study the effect of isotopes on rotational energies. 2. Students to estimate energy of harmonic vibrating molecules CO, HCl and plot the graph of vibrational energy versus vibrational quantum number 'v'. Analyse the nature of the graph and draw the inferences.	
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 defence 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**
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 Lab **(Practical)**		Practical Credits	**02**
Course Code	PHY C12-P		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.

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**

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.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**		Semester	**V**
Course Title	Mathematical Physics-I **(Theory)**			
Course Code:	PHY C13-T		No. of Credits	**04**
Contact hours	**60 Hours**		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks		**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

PO-1: Discipline Knowledge: Knowledge of science and ability to apply to relevant areas.
PO-2: Problem solving: Execute a solution process using first principles of science to solve problems related to respective discipline.
PO-3: Modern tool usage: Use a modern scientific, engineering and IT tool or technique for solving problems in the areas of their discipline.
PO-4: Ethics: Apply the professional ethics and norms in respective discipline.
PO-5: Individual and teamwork: Work effectively as an individual as a team member in a multidisciplinary team.
PO-6: Communication: Communicate effectively with the stake holders, and give and receive clear instructions.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) *(UGC guidelines)*	1	2	3	4	5	6
CO-1: Revise the knowledge of calculus, differential equations. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.	X	x				X
CO-2: Learn the vector calculus and their applications in physical problems such as electromagnetic fields etc.	X	x				
CO-3: Learn the basic properties of matrices, different types of matrices	X	x				
CO-4: Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc	X					
CO-5: Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems.	X			x	x	X
CO-6: Learn about Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.	X				x	X
CO- 7: Will get hands on experience of different mathematical software tools.	X	x	x		x	X

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course are Marked 'X' in the intersection cell if a course outcome addresses a particular program outcome.

Unit No.	Course Content	Hours
Unit I **Calculus:** Overview of Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions, Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). **First Order and Second Order Differential equations:** First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.		2 8
Activities Student shall develop an understanding of various aspects of harmonic oscillations and waves specially. (i) Superposition of collinear and perpendicular harmonic oscillations (ii) Various types of mechanical waves and their superposition.		3
Unit II **Vector Calculus:** **Overview of vectors:** Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **Vector Differentiation:** Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix.		12
Activities The students should acquire the skills of applying the SCILAB/MATLAB/MATHEMATICA software in solving standard physical problems. Solve the following problems using the Scilab programme: (i) Multiplication of two 3×3 matrices, (ii) Diagonalization of a matrix, (iii) Inverse of a matrix, Free **Scilab** software can be downloaded at https://www.scilab.org/download/scilab-6.1.1 or latest version		1
Unit III **Fourier Series:** Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.		10
Activities • Learn the basics of the **Scilab** software, their utility, advantages and disadvantages. • Apply the Scilab software in curve fittings, in solving system of linear equations, solving first and second order ordinary and partial differential equations. Fourier Series: Program to sum $\sum_{n=1}^{\infty} 0.2^n$		3

Evaluate the Fourier coefficients of a given periodic function (square wave)	
Unit IV **Integral Transforms** ***Fourier Transforms:*** Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Inverse Fourier transform, Convolution theorem. ***Laplace transform:*** Definition, transform of elementary functions , inverse transforms, transform of derivations, differentiation and integration of transforms, solutions of differential equations. **Frobenius Method for solving differential equations:** Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations.	13

Text Books

1. Mathematical Physics ---H. K. Dass and Dr. Rama VermaMathematical Methods for Physicists (4th Edition) George Arfken and Hans J. Weber Academic Press San Diego(1995).
2. Mathematical Physics - P.K. Chatopadhyay-Wiley Eastern Limited New Delhi (1990).
3. Introduction to mathematical Physics – Charlie Harper, Prentice-Hall of
4. India Private Limited New-Delhi (1995)
5. Mathematical Physics - M.L.Boas

Reference Books

1. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
2. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
3. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing.
4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. rd Bence, 3rd ., 2006, Cambridge Press
5. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications

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

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

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**		Semester	**V**
Course Title	Physics of Semiconductor Devices **(Theory)**			
Course Code:	PHY E1 - T		No. of Credits	**03**
Contact hours	**45 Hours**		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks		**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): To give knowledge about semiconductor physics, basic principles and discus the working and applications of basic devices, including pn junction, BJT's, FET and MOSFET,

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

- Explain the basic properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier injection/excitation.
- Explain the working, design considerations and applications of various semiconducting devices including p-n junctions, BJTs and FETs.
- Describe the working and design considerations for the various photonic devices like photodetectors, solar-cells and LEDs.

Unit No.	Course Content	Hours
Unit I **Semiconductor materials,** Review of crystal structure**:** Space Lattice, translational vectors, primitive and unit cells, Wigner-Seitz cell, Crystal system, crystal planes and Miller Indices, Concept of Reciprocal lattice (qualitative). Diamond structure. Concept of density of state for electrons in 3D metal (derivation), Fermi Dirac distribution (qualitative). **The semiconductor in equilibrium:** Energy bands in semiconductors, Charge carriers in semiconductors, the intrinsic and extrinsic carrier concentration and fermi level position. Concept of diffusion and doping mechanism (qualitative).		10
Unit II **Fundamental of semiconductor devices:** Basic structure of the pn junction. Zero applied bias: built in potential barrier, electric field, space charge width. Reverse applied bias: space charge width and electric field, Junction capacitance. Junction breakdown. **The pn Junction Diode**: Charge flow in a pn junction (qualitative). Ideal Current-Voltage relationship. Minority carrier distribution. Ideal pn junction current. Generation and recombination current.		10
Unit III **Metal–Semiconductor and Semiconductor Heterojunctions:** The Schottky barrier diode, qualitative characteristics, ideal and no ideal junction properties and barrier height. Current Voltage relationship**.** **Field-Effect Transistor:** JFET amplifying and switching, pinch off and saturation, Gate control I-V characteristics. MOSFET construction, 1D electron gas and inversion layer, Energy band diagram, MOSFET operation, MOS capacitor. Output and transfer		10

characteristics of MOSFET.	
Unit IV **Specialized Semiconductor Devices:** ***Optical devices****:* Optical absorption, photon absorption coefficient, electron-hole pair generation rate. Solar Cells: pn junction solar cell, ideal conversion efficiency, Fill factor, Equivalent circuit, $V_{OC,}$ I_{SC} and Load resistance. Photo detector, reverse saturation current. Light Emitting Diodes: principle, generation of light and quantum efficiency. Laser diode: stimulated emission and population inversion, optical cavity, electron and optical confinement, Heterojunction. ***Power devices****:* The basic characteristics and working of Tunnel diode, Gunn diode, Impatt diode, The thyristor.	10
Text Books: 1. Semiconductor Physics and Device, 4th ed., by D. Neamen and Drubesh Biswas, SIE Special Indian edistion. (https://www.optima.ufam.edu.br/SemPhys/Downloads/Neamen.pdf) 2. Solid State Physics, Ali Omar	
Reference Books: 1. Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006). 2. Sze, S.M., Physics of Semiconductor Devices, John Wiley, (1981). 3. Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, (2000). 4. Mishra, Umesh K. and Singh, Jaspreet, Semiconductor Device Physics and Design, Springer, (2008). 5. Pierret, R.F., Semiconductor Device Fundamentals, Pearson Education Inc., (2006).	

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

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

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Astronomy and Astrophysics **(Theory)**		
Course Code:	PHY E1 - T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

- Comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and measurement of distances, time and temperature and radius of star.
- Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram
- Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes.
- Understanding Physics of stars, atomic spectra, stellar spectra, Spectral classification, luminosity classification, temperature dependence.

Contents	xx Hrs
Unit-1 Basic concepts of Astrophysics Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time. Optical telescopes-types and characteristics, modern optical telescopes, reflecting and refracting telescopes, Detectors and their use with telescopes, astronomical instruments-photometer, photographic plates, spectrographs, CCD.	(7 hours) (5 hours)
Activities (3 hours) 1. Visit a nearby observatory and explore what types of telescopes and detectors are used. Prepare a report. 2. Describe the working principle of a CCD camera used in an observatory.	
Unit-2 Stellar Astrophysics Basic parameters of Stars: Determination of distance by parallax method, brightness, radiant flux and luminosity, apparent and absolute magnitude scale, distance modulus; Determination of temperature and radius of a star.	

(4 hours) Determination of masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell (H-R) diagram. Effective temperatures, colour indices. Saha's theory and ionization equation, Wilson-Bapu effect. (4 hours) Binary stars, optical spectroscopic and eclipsing binaries, radial and transverse velocities, masses of binary stars, rotational motion of stars, radii of stars. (4 hours)	
Activities (3 hours) Download CLEA software package. Several simulation experiments may be performed. http://public.gettysburg.edu/~marschal/clea/CLEAhome.html 1. Determine the atmospheric extension coefficient using optometric data using CLEA. 2. Classify the stars based on their spectra using CLEA	
Unit-3 Stellar structure Equations of stellar structure, boundary conditions, convective and radiative energy transport, stellar opacities, estimation of interior values, linear model, polytropes., Mass luminosity relation. (6 hours) Stages of stellar formation, time scales, life time on main sequence, evolution away from main sequence. Red giants, white dwarfs, neutron stars, black hole and supernova (general discussion), Chandrashekar limit. (6 hours)	
Activities (3 hours) 1. Estimate the surface temperature of the stars using CLEA 2. Determine the distance of Pleaedes clusters by main sequence fitting using CLEA	
References Books: 1. Introduction to Modern Astrophysics- Bradley W Carroll and D A Ostlie, Pearson Wesley, 2007 2. An Introduction to Astrophysics, 2nd Edition, Baidhyanath Basu, Prentice Hall of India Ltd, New Delhi, 2001 3. Astrophysics for Physicists – A Choudary, Cambridge Press 4. Astrophysics - A modern perspective- K.S. Krishnasamy, Reprint, New Age International Pvt. Ltd. New Delhi, 2002. 5. Textbook of Astronomy and Astrophysics with elements of cosmology- V.B. Bhatia, Narosa Publication.	
Employability and skill development The whole syllabus is prepared with a focus on employability. Skill development achieved: • Skills to learn and operate astronomical instruments to perform observations related to the positional astronomy measurement. • Conceptualize skills to understand basic parameters for describing the properties of stars and making experimental measurements, their interpretation and role in understanding of astrophysical phenomenon. Study of stellar spectra. **Job opportunities**: Lab Assistant/Scientific Assistant in Astronomical Observatories	

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

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

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Elements of Nano Science **(Theory)**		
Course Code:	PHY E1 – T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 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:

- Understand the fundamental principles of nanoscience and develop a comprehensive understanding of the basic principles, theories, and concepts related to nanoscience, including the definitions, Nanoforms of Carbon, General Methods of Preparation, Characterization Techniques and its applications.
- Apply the principles of nanoscience to solve real-world problems.
- Communicate effectively about nanoscience to both technical and non-technical audiences. This includes being able to explain the basic concepts of nanoscience in clear and concise language, as well as being able to discuss the potential benefits and risks of nanotechnology.

Unit No.	Course Content	Hours
Unit I **Introduction:** Length scales, Surface, size, shape and assembly effects. Classifications of nanostructured materials- nano particles- quantum dots, nanowires-ultra-thin films. Variation of physical properties from bulk to thin films to nanomaterials, - confinement of electron energy states in 0D, 1D,2D and 3D systems, density of states equation and graph (qualitative treatment). **Nanoforms of Carbon** – Buckminster fullerene- graphene and carbon nanotube, Single wall carbon Nanotubes (SWCNT) and Multi wall carbon nanotubes (MWCNT). Mechanical, Electronic, Optical, Magnetic and Thermal properties of nano materials (qualitative).		10
Unit II **General Methods of Preparation:** Top-down Techniques: Mechanical grinding (Ball milling), Lithography, Etching and Erosion. Bottom-up Techniques: Co-Precipitation, Colloidal routes, Chemical vapour phase deposition, MOCVD, Plasma CVD. Physical Vapour Deposition: Sputtering, thermal evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.		**10**
Unit III **Characterization Techniques:** X-ray Diffraction: Braggs law, Bragg's X ray spectrometer. XRD pattern, intensity vs 2θ plot. Particle size analysis using Debye Scherrer formula. Scanning Electron Microscopy, Transmission Electron Microscopy. Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS-Nanoindentation.		10

Unit IV **Applications:** Nano InfoTech: Information storage- nanocomputer, molecular switch, super chip, nanocrystal, Nanobiotechlogy: nanoprobes in medical diagnostics and biotechnology, Nano medicines, Targetted drug delivery, Bioimaging – Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)- Nanosensors, nano crystalline silver for bacterial inhibition, Nanoparticles for sunbarrier products.	10
Text Books: 1. Nano Materials- A.K.Bandyopadhyay/ New Age Publishers. 2. Nanocrystals: Synthesis, Properties and Applications. C. N. R. Rao, P. John Thomas and G. U. Kulkarni, Springer Series In Materials Science. 3. Nano Essentials- T.Pradeep/TMH 4. A.S. Edelstein and R.C. Cammearata, eds., —Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing, Bristol and Philadelphia, 1996.	
Reference Books: 1. G Timp, —Nanotechnology, AIP press/Springer, 1999. 2. Akhlesh Lakhtakia,—The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations. Prentice-Hall of India (P) Ltd, New Delhi, 2007. 3. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al. 4. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004. 5. Processing & properties of structural naonmaterials - Leon L. Shaw, 6. Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005. 7. N John Dinardo, —Nanoscale Charecterisation of surfaces & Interfaces, 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000.	

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

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

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Atmospheric Physics **(Theory)**		
Course Code:	PHY E1 – T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

- Understand Earth's atmosphere, its composition, effective temperature, Greenhouse effect. Hydrostatic equation and atmospheric thermodynamics. Local winds, clouds, fog, monsoon, cyclones, sea breeze and land breeze and thunderstorms etc.
- Describe instruments for meteorological observation, meteorological processes and systems.
- Understanding of atmospheric waves.
- Explain the classification and properties of aerosols, their concentrations and size distribution.
- Understanding the absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Boyer-Lambert law, optical phenomenon in atmosphere. Basics of radiometry.
- Study atmospheric parameters and their variation through computer simulations in the laboratory using data available from AWS, the student learn to.

Contents	60 Hrs
Basic concepts of Atmospheric Physics Introduction to Meteorology or Atmospheric Science as a multidisciplinary subject, coordinate system, longitude and latitudes, velocity components, optical properties and mass of the atmosphere, chemical composition of the atmosphere, fixed and variable gases and their VMR, sources and sinks of atmospheric gases, air density and air pressure, Variation of pressure with altitude, physical structure of the atmosphere, temperature structure of the atmosphere, hydrostatic equation, potential temperature, Atmospheric thermodynamics, and effective temperature of the earth. (7 hours) Winds in the atmosphere, monsoon, fogs, clouds and precipitation, Atmospheric boundary layer, sea breeze and land breeze, cyclones and thunderstorms. (5 hours) **Activities (3 hours)** 1. Write a computer code in C to simulate altitude from the given pressure data. 2. Make use of GPS-RS data, compute potential temperature at various heights	15

2 Sun's radiation Sun's radiation spectrum, Black body radiation, Planck's law, emission curves from the sun and the earth atmosphere, Absorption and scattering (Rayleigh and Mie scattering) of solar radiation by earth's atmosphere, absorptivity, emissivity, Kirchoff's laws, reflectivity and transmission, Beer's law (derivation), Global energy balance, Green House Effect. (6 hours) Meteorological instruments and atmospheric observations, Measurement of temperature, humidity wind and pressure. Meteorological instruments - wet and dry bulb thermometers, rain gauge, anemometer, ground based, air borne and space borne techniques of measurements of atmospheric parameters, Atmospheric aerosols- classification, properties and observational techniques for aerosols. (6 hours) **Activities (3 hours)** 1. Using wet and dry bulb thermometers, collect temperature data over a period and determine the relative humidity and its variation. 2. Design your own tipping bucket rain gauge and monitor the rain fall during monsoon.	15
Unit-3 Atmospheric dynamics Scale analysis, Fundamental forces, Basic conservation laws, The vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Centripetal and Coriolis force (derivation), Gravity and pressure gradient forces (with derivation), Applications of Coriolis force – Formation of trade winds, cyclones, erosion of river banks. (7 hours) Waves in the atmosphere- Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non-homogeneous medium, Lamb waves, Rossby waves and its propagation. (5 hours) **Activities (3 hours)** 1. Scilab/C^{++} simulation experiments: Numerical simulation of atmospheric waves using dispersion relations. 3. Collect Radiosonde data and interpret in terms of atmospheric parameters using vertical profiles in different regions of the globe.	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**

Total	**40 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1	Basics of Atmospheric Science - A Chandrasekar, PHI Learning Private Limited, Eastern Economy Edition, 2010
2	Weather, Climate and Atmosphere - Siddartha.
3	Atmospheric Science - John M Wallace and Peter V Hobbs, Elsevier Publications, 2006.
4	Introduction to Atmospheric Science - Turberick and Lutzens, Elsevier Publications
5	Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
6	The Physics of Atmosphere – John T. Houghton; Cambridge Press, 3rd Edition. 2002.
7	An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
8	Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

Employability and skill development

The whole syllabus is prepared with a focus on employability.

Skill development achieved:

- Develop skills to describe, understand and make measurements of various parameters to describe the physics of earth's atmosphere.
- Measure and work with various meteorological instruments like rain gauge, wet and dry bulb thermometers, anemometer,
- Develop a theoretical and experimental understanding of the absorption and scattering of solar radiation with matter.
- Use of software packages for simulation of atmospheric phenomena.

Job opportunities: Technical Assistant/Scientific Assistant in Meteorology Department, Weather stations, Tropical meteorology institutes.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Electrical Circuits and Network Skills **(Theory)**		
Course Code:	PHY V1 - T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

- Understand the fundamental concepts of electrical circuits and networks.
- Analyze the behavior of a simple electrical circuit.
- Design a circuit to meet a specific set of requirements.
- Apply the principles of electrical circuits and networks to solve real-world problems.
- Troubleshoot an electrical circuit that is not working properly.
- Analyze the behavior of an electrical network.
- Communicate effectively about electrical circuits and networks to both technical and non-technical audiences.

Contents	45 Hrs
Basic Electricity Principles: Voltage, Current, Resistance and Power. Series, Parallel and Series-Parallel combinations of circuit elements. Familiarization with voltmeter, ammeter and multimeter. 2 hours **Electrical circuits:** Electric circuit elements and their combinations, Rules to analyze DC electrical circuits, Network theorems, current and voltage drop across DC circuit elements. Single phase and three phase alternating current sources. Rules to analyze AC sourced electrical circuits. Power factor. Economic operation with power factor correction. 2 hours **Electrical drawing and symbols:** Rules for electrical drawing, electric and electronic symbols, Blueprints, Schematics, Ladder diagrams. Power circuits and control circuits. Tracking circuit element connections and identify current flow and voltage drop. PCB designing and fabrication. 2 hours **Generators and Transformers:** DC Power sources. AC and DC generators, Impedance. Transformers-Principle, Construction and Operation, Electrical Induction- Induction Cooktop, Wireless Charging. 2 hours **Electric motors:** Single phase and three phase AC motor, DC motors, BLDC motor, Capacitor Coupling, AC regulator, Interfacing DC or AC sources to control motors. RPM and Power Consumption of AC motors. 2 hours	

Electrical Protection and Solid-State Devices: Grounding and isolation, Phase reversal, Surge protection, Fuses and disconnect switches, Circuit breakers, Overload Devices. Relay, Timer relay, Voltage controller, SMPS, LED. 2 hours **Electrical Wiring:** Colour coding of wires, wire gauge. Different types of conductors and cables. Basics of wiring, voltage drop and losses across cables and conductors. Electrical insulation, Single and multi stranded cable. Conduit wiring, cable trays. Splices, wirenut, crimps, terminal blocks, split bolts, solder and applications. 3 hours	
Practicals: 1. Verification of Thevenin and Norton theorem. 2. Verification of Millman's theorem. 3. IV characteristics of a solid state relay. 4. Capacitor coupled power supply. 5. Load regulation and line regulation of an SMPS Power Supply. 6. TE model characterization using Peltier Cooler 7. Voltage controller using a 3 pin IC 8. IV characteristics of a buck boost converter 9. Monostable multivibrator using IC 555 10. LDR characteristics	

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

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

Text Books

Sl No	Title of the Book
1	A text book in Electrical Technology-BL Theraja- S Chand and Company
2	Performance and design of AC machines- M G Say –ELBS Edn

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Renewable Energy and Energy Harvesting **(Theory)**		
Course Code:	PHY V1 - T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**50**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

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

- Understand the fundamental concepts of renewable energy and energy harvesting.
- Apply the principles of renewable energy and energy harvesting to solve real-world problems.
- Describe the environmental aspects of non-conventional energy resources in comparison with various conventional energy systems, their prospects and limitations.
- Understand the concept of Hydropower plant resources and their classification, types and applications
- Describe the use of solar energy and the various components used in the energy production.
- Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.
- Understand the concept of Biofuel energy resources and their classification, types and applications

Contents	**45 Hrs**
Fundamentals of Solar Energy Cells and PV Modules: Solar radiation - Solar Spectrum, Solar Radiation at a Given Location, Annual Variation in Solar Radiation, Domestic and commercial solar thermal applications, solar collectors, heat exchangers, solar dryers. (2 Hrs) Operation of p-n junction Solar Cell, I-V Characteristics Status of Photovoltaic Technologies, Solar cell types, Solar Cell parameters, Efficiency of solar cells and PV modules, Types of modules, Characteristic I-V curves for modules (3 Hrs)	
Basic Electricity and Hydro Power Hydropower plant - Selection of Site - Classification of turbines - combined cycle power plants, Domestic and commercial Hydro power production, Electricity distribution and wiring, Power cables, Estimation of Energy Production and transmission, Applications of on-grid and off-grid and Hybrid Power, and Stand-Alone system. (3 Hrs)	
Biofuel & **Wind Energy** Liquid biofuel: Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization, Alcohol production from biomass, Combustion in excess oxygen and oxygen deficient atmosphere. Different types-power generation from gasification. (3 Hrs) Introduction to wind energy, Wind Resources, Wind Shear, Wind Maps, Wind Turbines, Small Wind Turbines, Overview of energy plantation. Large Scale Wind Farms (2 Hrs)	

Practicals: 1. Construct and study a solar drying system model 2. Thermocouple – Seebeck effect (To verify the relation between thermo emf of a thermocouple and temperature difference between two hot junctions) 3. Determination of Specific heat capacity of water by heating coil method. 4. LDR characteristics. 5. Estimation of specific heat of biodiesel. 6. Characteristics of Photodiodes 7. Study of solar lighting using solar panel 8. Study of voltage versus distance curve of a solar cell 9. Study of the effect of filters on the voltage of a solar cell 10. Kinetic energy and velocity of a fluid using pressure head 11. Determination of Reynold's number 12. Determination of surface tension of a liquid by capillary rise method.	

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

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

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.

Text Books

Sl No	**Title of the Book**	**Authors Name**	**Publisher**	**Year of Publication**
1	Introduction to renewable Energy (energy and the environment series)	Vaughn Nelson	CRC Press Taylor & Francis Group	2011
2	Physics with Modern Physics	Hugh D. Young, Freedman Roger A.	14th Edition | By Pearson	

References Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Alternative Energy Systems and Applications	B. K. Hodge	Hoboken, NJ: John Wiley & Sons	2017
2	Fundamentals and Applications of Renewable Energy	Mehmet Kanoglu, Yunus Cengel, John Cimbala	McGraw-Hill Education	2020
3	Renewable Energy Resources	John Twidell and Tony Weir	Taylor & Francis	2006
4	Understanding Renewable Energy Systems	Volker Quaschning	Earthscan (science publishers)	2005
5	Wind Energy Engineering, A Handbook for Onshore and Offshore Wind Turbines		Academic Press	2017
6	Solar energy: The physics and engineering of photovoltaic conversion, technologies and systems	Arno HM Smets, Klaus Jäger,Olindo Isabella, René ACMM van Swaaij Miro Zeman	UIT cambridge	2015
7	Fundamentals of Renewable Energy Processes	Aldo Vieira da Rosa, Juan Carlos Ordonez	Academic Press	2021
8	non-conventional energy resources	G. S. Sawhney	Phi learning private limited	2012
9	Non-conventional Energy Sources	G. D. Rai	Khanna Publishers	2001

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Computational Physics Skills (Physics problem solving using C++ or Python) **(Theory)**		
Course Code:	PHY V1 - T	No. of Credits	**03**
Contact hours	**Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**50**	Summative Assessment Marks	

Course Pre-requisite(s):

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

- Understand different types of computing architectures.
- Understand basic concepts of computer hardware and software.
- Use data representation for the fundamental data types and perform conversions between binary-hexadecimal-decimal representations.
- Describe the architectures of open-source Linux kernel and commercially available windows kernel.
- Write and test basic scientific programs using Python by understanding looping structures, functions and arrays.
- Use a modern development environment to develop and debug code.
- Explore the richness of libraries in Python which are effectively used in various Physics problems and data analysis.
- Develop competency in applying coding skills in scientific computations.
- Acquire data analysis and visualization skills

Contents	xx Hrs
DSE:PHY E1-T Computational Physics Skills (Physics problem solving using Python) (3 CREDITS, 3 HOURS PER WEEK) **Unit-1: Fundamentals of computing** - History, Computing Architectures: (Classical, Quantum Neuromorphic, Reservoir, etc), Von Neumann architecture. Basic Organisation of computer: Memory: ROM, RAM, PROM, EPROM, EEPROM, Secondary Memory: Hard Disk and optical Disk, Cache Memory, I/O devices, Features of Digital Systems, Number Systems- Decimal, Binary, Octal, Hexadecimal and their inter conversions, Representation of Data: Signed Magnitude, one's complement and two's complement, Binary Arithmetic, Fixed point representation and Floating-point representation of numbers, Operating Systems: Windows and Linux, Algorithms and flowcharts, Languages, Applications (13 hours) **Activities:** Group presentations on various computing architectures, operating systems, and other topics covered in unit-1(2 hours) ***	

Unit-2: Introduction to Python - Philosophy and structure (Object-Oriented, Modular, platform-independent, Scripted, etc), Data types, Boolean and arithmetic Operations,
Loops, Functions, Arrays. (12 hours)

Activities: Writing and debugging simple python codes for I/O operations, strings, arrays (linear algebra), functions etc (standard functions) (3 hours)

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Unit-3: Libraries in Python - General listing (from scientific calculations to webpage building, big data handling, visualization, machine learning/AI); Focus on Numpy, Scipy, Matplotlib and Sympy with specific Physics examples (Linear equation systems, line integrals, surface integrals-flux, volume integrals-electric field due to charge distribution. (13 hours)

Activities: Write a program to find the trajectory of a satellite in a circular orbit about a planet as seen from a planet in a circular orbit around the sun. (2 hours)

Other activities: (pseudo-code may be given, and students will be asked to develop the program, or actual code may be given with bugs, and students can be asked to debug and explain the working of the code, and implement certain modifications)

Physics problems

- Solution to transcendental equations: Bisection method, Newton-Raphson method and Secant method.
- To calculate the launch angle for a projectile launcher so that the projectile hits a desired target
- Euler's method and Runge-Kutta method implementation: Solving first order differential equations: Radioactive decay law, body falling in a viscous medium,
- Superposition of two sine waves of similar wave number that produce beats
- Circuit simulator (LCR, constant phase element)
- Numerical differentiation and integration
- Fast Fourier transform - Convolution integrals
- Curve fitting of scatter data: Linear fit
- Visualization: 2D and 3D plotting of data, histograms, pie charts, linear and log axes
- Image analysis: Conversion to B/W, identifying contours/edges, extracting features etc.

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

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Total	**40 Marks**

Formative Assessment as per UNIVERSITY guidelines are compulsory

References	
1	Computer organization and Architecture by V. Rajaraman, T. Radhakrishnan, PHI Leaning Private Ltd.
2	Operating Systems Design and Implementation, Andrew S. Tanenbaum, Albert S. Woodhull, Alfred Woodhull, Prentice Hall Ltd.
3	Computer Fundamentals: Architecture and Organization by B.Ram, New Age International Ltd.
4	Essential Python for the Physicist, Giovanni Moruzzi, Springer.
5	Computational Physics Problem Solving with Computers, eTextBook Python 3rd Edition, Landau, Paez & Bordeianu
6	Numerical Methods in Physics with Python, ALEX GEZERLIS, Cambridge Press.
7	Numerical Python Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib, Second Edition, Robert Johansson, Apress (2019).
8	Introduction to Python Programming by Gowrishankar. S and Veena.A, CRCpress

Government of Karnataka

Model Curriculum

Program Name	**BSc**	Semester	VI
Course Title	Elements of Condensed Matter & Nuclear Physics		
Course Code:	PHY C14 - T	No. of Credits	**4**
Contact hours	**60 Hours**	Duration of SEA/Exam	**3 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:

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

Contents	**60 Hrs**
Crystal systems and X-rays: Crystal structure**:** Space Lattice, Lattice translational vectors, Basis of crystal structure, Types of unit cells, primitive, non-primitive cells.. Seven crystal system, Coordination numbers, Miller Indices, Expression for inter planner spacing. **X Rays**: Production and properties of X rays, Coolidge tube, Continuous and characteristic X-ray spectra; Moseley's law. **X-Ray diffraction**, Scattering of X-rays, Bragg's law. **Crystal diffraction:** Bragg's X-ray spectrometer- powder diffraction method, Intensity vs 2θ plot (qualitative). **Free electron theory of metals:** Classical free electron model (Drude-Lorentz model), expression for electrical and thermal conductivity, Weidman-Franz law, Failure of classical free electron theory; Quantum free electron theory, Fermi level and Fermi energy, Fermi-Dirac distribution function (expression for probability distribution F(E), statement only); Fermi Dirac distribution at T=0 and $E<E_f$, at $T\neq 0$ and $E>E_f$, F(E) vs E plot at T = 0 and $T\neq 0$. Density of states for free electrons (statement only, no derivation). Qualitative discussion of lattice vibration and concept of Phonons.; Specific heats of solids: Classical theory, Einstein's and Debye's theory of specific heats. Hall Effect in metals.	15 Hrs
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.	
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)	15 Hrs
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	15 Hrs
Suggested Activities:	
1) Students to construct seven crystal systems with bamboo sticks and rubber bands. Use foam ball as atoms and study the BCC and FCC systems. 2)Students to search the characteristic X ray wavelength of different atoms/elements and plot characteristic wavelength vs atomic number and analyse the result and draw the inference. 3)Magnetic field lines are invisible. Students to trace the magnetic field lines using bar magnet and needle compass. https://nationalmaglab.org/magnet-academy/try-this-at-home/drawing-magnetic-field-lines/ , 4)Using vegetable oil and iron fillings students to make ferrofluids and see how it behaves in the presence of magnetic field. https://nationalmaglab.org/magnet-academy/try-this-at-home/making-ferrofluids/ 1) Study the decay scheme of selected alpha, beta & gamma radioactive sources with the help of standard nuclear data book. 2) Calculate binding energy of some selected light, medium and heavy nuclei. Plot the graph of binding energy versus mass number A 3) Study the decay scheme of standard alpha, beta and gamma sources using nuclear data book. 4) Make the list of alpha emitters from Uranium series and Thorium series. Search the kinetic energy of alpha particle emitted by these alpha emitters. Collect the required data such as half life or decay constant. Verify Geiger-Nuttal in each series. 5) Study the Z dependence of photoelectric effect cross section. 6) Study the Z dependence of common cross section for selected gamma energies and	

selected elements through theoretical calculation. 7) List the materials and their properties which are used for photocathode of PMT. 8) Study any two types of PMT and their advantages and disadvantages.	

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

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

References

Text Books

1. Solid State Physics-R. K. Puri and V.K. Babber., S.Chand publications,1st Edition(2004).
2. Fundamentals of Solid State Physics-B.S.Saxena,P.N. Saxena,Pragati prakashan Meerut(2017).
3. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
4. Nuclear Physics, Irving Kaplan, Narosa Publishing House

Reference Books

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

Course Title	Elements of Condensed Matter & Nuclear Physics Lab **(Practical)**	Practical Credits	**02**
Course Code	**A15**	Contact Hours	**XX Hours**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

CONDENSED MATTER PHYSICS

1. Determination of Plank's constant by Photo Cell
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.
7. Plank's constant by LED
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**
Total	**25 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

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

Government of Karnataka

Model Curriculum

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

Course Pre-requisite(s):

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

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

Contents	60 Hrs
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. (5 hours) **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. (5 hours) *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.* **Activities (3 hours)** 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-II: Wave form generators and Filters Basic principle of standard AF signal generator: Fixed frequency and variable frequency, AF sine and square wave generator, basic Wein-bridge network and oscillator configuration, Triangular and saw tooth wave generators, circuitry and waveforms. (5 hours) 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. (5 hours) **Activities (3 hours)** 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.	
Unit-III: 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. (4 hours) Digital display systems and Indicators- Classification of displays, Light Emitting Diodes (LED) and Liquid Crystal Display (LCD) – Structure and working. (3 hours) 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). (3 hours) *Topic for self-study*: *Lock-in amplifier and its application, phase locked loop*. **Activities (3 hours)** 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-IV: 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. (10 hours) **Activities (3 hours)** 1. Construct your own thermocouple for the measurement of temperature with copper and constantan wires. Use the thermocouple and a Digital multimeter (DMM). Record the emf (voltage induced) by maintaining one of the junctions at a constant temperature (say at 0^{o} C, melting ice) and another junction at variable temperature bath. Tabulate the voltages induced and temperatures read out using standard chart (Chart can be downloaded from the internet). 2. Observe a solar water heater. Some solar water heaters are fitted with an anode rod (alloy of aluminium). Study why it is required. Describe the principle behind solar water heater.	

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

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

References

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

Course Title	Electronic Instrumentation & Sensors Lab **(Practical)**	Practical Credits	**2**
Course Code	PHY C17 - P	Contact Hours	**4 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 low 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**
Total	**25 Marks**
Formative Assessment as per University guidelines are compulsory	

References

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

Employability and skill development

The whole syllabus is prepared with a focus on employability.
Skill development achieved: Fundamental understanding of the working of test and measuring instruments. Operating and using them for measurements. Servicing of laboratory equipment for simple cable faults, loose contacts and discontinuity.

Job opportunities: Lab Assistant/Scientific Assistant in hospitals, R and D institutions, educational institutions.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Electrodynamics and Statistical Physics **(Theory)**		
Course Code:	PHY C18 - T	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite (s): PUC Science Knowledge

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

- Describe basics of electrodynamics.
- Explain EM wave propagation in unbounded media.
- Apply classical statistics to physical situations.
- Apply quantum statistics to physical problems.

Contents	Hours
Unit 1: Basics of Electrodynamics Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **12 Hours** **Activities: 03 Hours** 1. Students to study the physical meaning of divergence and curl operators and apply the knowledge to understand Maxwell's equations. Present the study by PPT presentation. 2. Students to identify different wave equations in physics and learn to solve the equations by different techniques.	**15**
Unit 2: EM Wave Propagation in Unbounded Media Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. EM wave propagation in optical fibers. **12 Lectures** **Activities: 03 Hours** 1. Students to identify optical fibers used in different applications and record their characteristics. 2. Students to identify radiation sources used in mobile communication and list their characteristics (2G/3G/4G/5G).	**15**
Unit 3: Classical Statistics Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) –Applications to	**15**

Specific Heat and its Limitations. **12 Hours** **Activities:** **03 Hours** 1. Students to learn Binomial distribution using coins and plot the distribution curve. 2. Students to learn Normal distribution using nails and plot the distribution curve.	
Unit 4: Quantum Statistics Bose-Einstein distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **12 Hours** **Activities:** **03 Hours** 1. Students to list particles belonging to Bosons and Fermions, and understand their characteristics . Students also make the presentation of the study. 2. Students to search the contribution of Indian scientist J.C. Bose in Bose-Einstein condensation. Students also make the presentation of the study.	**15**

Text Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
3. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
5. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford University Press.

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

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

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Radiology Equipment and Radiation Safety **(Theory)**		
Course Code:	PHY V2-T	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**50**	Summative Assessment Marks	**50**

Course Pre-requisite(s):

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

- Understand the fundamental principles of radiation physics and radiation safety management.
- Apply the principles of radiation physics and radiation safety management to the operation of radiology equipment.
- Assess the radiation risk associated with different radiographic procedures.
- Communicate effectively about radiation safety to both technical and non-technical audiences.

Contents	30 Hrs
Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section.	(6 Lectures)
Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons** - Photoelectric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients.	(7 Lectures)
Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). **Radiation detection**: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.	(7 Lectures)
Radiation safety management: Biological effects of ionizing radiation, Operational Limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.	(5 Lectures)
Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.	(5 Lectures)

Experiments: 1. Study the background radiation levels using Radiation meter Characteristics of Geiger Muller (GM) Counter: 2. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source). 3. Study of counting statistics using background radiation using GM counter. 4. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage. 5. Study of absorption of beta particles in Aluminum using GM counter. 6. Study of absorption of gamma particles in Aluminum using GM counter 7. Verification of inverse square law using GM counter 8. Detection of α particles using reference source & determining its half life using spark counter 9. Gamma spectrum of Gas Light mantle (Source of Thorium)	

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

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

References	
1	G.F.Knoll, Radiation detection and measurements
2	W.J. Meredith and J.B. Massey, “Fundamental Physics of Radiology”. John Wright and Sons, UK, 1989.
3	J.R. Greening, “Fundamentals of Radiation Dosimetry”, Medical Physics Hand
4	Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
5	Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge Press, U.K., 2001
6	A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
7	NCRP, ICRP, ICRU, IAEA, AERB Publications.
8	W.R. Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc. London, 1981

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**		Semester	**V**
Course Title	Applied Optics **(Theory)**			
Course Code:	PHY V2-T		No. of Credits	**03**
Contact hours	**45 Hours**		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks		**50**	Summative Assessment Marks	**50**

Course Pre-requisite(s):	
Course Outcomes (COs): After the successful completion of the course, the student will be able to: CO1. Specify the holistic view of lasers, lasing action and Fourier optics. CO2. Describe the importance of basic concepts related to holography and applications CO3. Demonstrate the basics of optical fiber and types of optical fibers.	
Contents	**45 Hrs**
Unit-1: Sources & Detectors and Fourier Optics: Lasers, Spontaneous and stimulated emissions, Theory of laser action, Three level and four level lasers Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers. Fourier Optics: Concept of Spatial frequency filtering, Fourier transforming property of a thin lens. **12 hours** **Activities**: **3 hours** 1. Identify the various LASER sources and detectors available in the market. 2. List out the different LASERs used in medical and defence field.	
Unit-2: Holography Basic principle and theory: coherence, resolution, Types of holograms, basic principles, recording and reconstruction process, white light reflection hologram, requirements for holographic recording, recording materials, computer generated holograms, digital holography. Application of holography in microscopy, interferometry, and character recognition - laser beam steering, holographic data storage, holographic image guide for AR devices. **12 hours** **Activities**: **3 hours** 1. Write the specification of various optical devices used in the industries. 2. List out the various applications of holography.	
Unit-3: Photonics – Fiber Optics Optical fibers and their properties, Principal of light propagation through a fiber, The numerical aperture, Attenuation in optical fiber and attenuation limit, Single mode and multimode fibers, Fiber optic sensors: Fiber Bragg Grating. **12 hours** **Activities**: **3 hours** 1. Identify various types of optical fiber cables and their applications.	

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

Course Title	Applied Optics **(Practical)**		Practical Credits	**XX**
Course Code	PHY V2-T		Contact Hours	**XX Hours**
Formative Assessment	**25 Marks**	Summative Assessment		**25 Marks**
Practical Content				

List of Experiments

1. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
2. To find the polarization angle of laser light using polarizer and analyzer.
3. Study of V-I characteristics of LED.
4. Study the characteristics of solid state laser.
5. Characteristics of IR sensor.
6. Optical image addition/subtraction.
7. Optical image differentiation.
8. Fourier optical filtering.

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**
Total	**25 Marks**
Formative Assessment as per UNIVERSITY guidelines are compulsory	

References	
1.	Basics of Laser Physics: For Students of Science and Engineering, Karl F. Renk, 2nd Edition, 2017, Springer International Publishing AG 2017.
2.	Textbook on Optical Fiber Communication and Its Applications, S. C. Gupta, 2004, Prentice Hall India Learning Private Limited.
3.	Optical Fiber Communications – Principles and Practices. Systems and Processes, John M. Senior, 2006, Pearson Education.
4.	Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
5.	LASERS: Fundamentals & applications, K. Thyagrajan & A. K. Ghatak, 2010, Tata McGraw Hill.
6.	Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7.	Optical Physics, A. Lipson, S. G. Lipson, H. Lipson, 4th Edition, 1996, Cambridge Univ. Press.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Physics**	Semester	**V**
Course Title	Theoretical Modeling and Simulation using DFT/ FTDT/ COMSOL **(Theory)**		
Course Code:	PHY V2-T	No. of Credits	**03**
Contact hours	**Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**50**	Summative Assessment Marks	

Course Pre-requisite(s):

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

- Understand the fundamental principles of density functional theory (DFT), finite-temperature density functional theory (FTDT), and COMSOL.
- Apply the principles of DFT, FTDT, and COMSOL to solve real-world problems
- Communicate effectively about theoretical modeling and simulation to both technical and non-technical audiences.
- Develop a comprehensive understanding of theoretical modeling and simulation techniques commonly used in physics.

Contents	xx Hrs
Unit 1 : Basics of crystal structure The Symmetry Groups in Three-Dimensional Space, Classification of the Symmetry Groups, Translation and Point Symmetry of Bulk Crystals, Bulk Crystal Structures: Structures with Cubic Lattices, Structures with Tetragonal and Orthorhombic Lattices, Structures with Hexagonal Lattices. Concept of reciprocal lattice. Visualization tools such as Xcrysden, Vesta, ASEGUI, Avogadro to understand the crystal structures and reciprocal lattices using CIF file (Crystallographic information file) from Materials cloud website. (13 hours). **Activities:** 1. Identify symmetry elements in Silicon primitive cell using Vesta and prepare a report. 2. List the symmetry elements in graphene using Bilbao crystallographic server: https://www.cryst.ehu.es 3. Study the reciprocal lattice of FCC and BCC structures by choosing the relevant CIF files using Xcrysden or ASEGUI and make a report.	(13 hours).
Unit 2: Introduction to Density Functional theory Basis Sets and Pseudopotentials, Plane Wave, Localized Atomic Functions Basis Sets and Gaussian Basis Sets (qualitative), Hartree method: One-electron model. Introduction to Density functional theory (DFT): Hohenberg–Kohn theorems, Kohn–Sham approach, Exchange-correlation functionals (qualitative), Local density approximation, Generalized density approximation, Solving Kohn–Sham equations using self consistency method, Total energy and other properties. k-point sampling in reciprocal space, Bloch theorem, Plane wave expansions, Cut-off energy, Smearing, Electronic minimizations, Ionic minimizations. (13 hours) **Activities:**	(13 hours)

1. Using Interactive Modeling of Materials with DFT Using Quantum ESPRESSO (DFT code) within the MIT Atomic ScaleToolkit: https://www.youtube.com/watch?v=tRAhPLIyDiQ, construct band struture of silicon. 2. Using this link https://www.youtube.com/watch?v=MPuJC0xE6UA install Quantum espresso and make a report of the steps followed in the installations procedure.	
Unit 3: Molecular Dynamics (MD) **Introduction:** Atomic model in MD, Classical mechanics, Potentials: Pair potentials, Embedded atom method potentials, Tersoff potential, Potentials for ionic solids, Reactive force field potentials Solutions for Newton's equations of motion: N-atom system, Verlet algorithm, Velocity Verlet algorithm, Predictor–corrector algorithm, Initialization: Potential cutoff, Periodic boundary condition, Neighbor lists, Number of atoms (system size), Initial positions and velocities, Timestep, Total simulation time, Type of ensemble, Integration/equilibration: Temperature and pressure control, Minimization in a static MD run, Energies, Structural properties, Mean-square displacement, Energetics, thermodynamic properties, and others. (13 hours)	(13 hours)

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

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

Course Title	Theoretical Modeling and Simulation using DFT/ FTDT/ COMSOL **(Practical)**	Practical Credits	**XX**
Course Code	PHY V2-T	Contact Hours	**XX Hours**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**
Practical Content			

1. Basic introduction and Implementation in Python: https://klyshko.github.io/teaching/2019-03- 01-teaching

a) One particle projectile motion
b) Three interacting particles
c) Molecular dynamics of proteins

2. Equilibration to Maxwell-Boltzmann distribution: Simulation of a 2D gas (https://scipython.com/book2/chapter-4-the-core-python-language-ii/examples/a-simple-2d-molecular-dynamics-simulation/)
3. Small protein in water solution using GROMACS: https://tutorials.gromacs.org/md-intro-tutorial.html
4. Molecular dynamics with Python: https://www.scm.com/doc/Tutorials/MolecularDynamicsAndMonteCarlo/MDintroPython/intro.html
5. Determine the band structure of GaAs using quantum espresso code and evaluate the energy gap.
6. Determine the reciprocal lattice for 1D, 2D (square lattice) and 3D (Cube) lattice and identify the different planes of lattice with points in reciprocal lattice

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

References	
1	Computational Materials Science: AN INTRODUCTION, SECOND EDITION, June Gunn Lee, CRC group, Taylor and Francis group.
2	ELECTRONIC STRUCTURE OF MATERIALS, Rajendra prasad, CRC group, Taylor and Francis group.
3	Materials Modelling using Density Functional Theory, Properties and Predictions, Feliciano Giustino, Oxford Press.
4	Density Functional Theory A Practical Introduction, David S. Sholl, Janice A. Steckel
5	Physics of Condensed Matter, Prasanta K. Misra, Elsevier.
6	https://nanohub.org/resources/7570
7	Chapter in “Computational many-particle physics (Springer): https://drive.google.com/file/d/1vRUA2ifTXZKEFaFDKNSrs373dg4DSBev/view?usp=sharing
8	Article in American Journal of Physics: https://arxiv.org/pdf/2001.07089.pdf