ST. JOSEPH'S UNIVERSITY

BENGALURU-27

DEPARTMENT OF PHYSICS

SYLLABUS FOR POSTGRADUATE PROGRAMME

For Batch 2024-2025

<table>
<tr><th colspan="4">Part A</th></tr>
<tr><td>1</td><td>Title of the Academic Program</td><td colspan="2">MSc Physics</td></tr>
<tr><td>2</td><td>Program Code</td><td colspan="2">(To be given by Examination Section)</td></tr>
<tr><td>3</td><td>Name of the University</td><td colspan="2">St. Joseph’s University</td></tr>
<tr><td>4</td><td>Objective of the University</td><td colspan="2">1. Academic Excellence
2. Character Formation
3. Social Concern</td></tr>
<tr><td>5</td><td>Vision of the University</td><td colspan="2">“Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized”</td></tr>
<tr><td rowspan="4">6</td><td rowspan="4">Mission of the University</td><td>M1</td><td>St. Joseph's College (Autonomous) seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.</td></tr>
<tr><td>M2</td><td>The education offered is oriented towards enabling students to strive for both academic and human excellence.</td></tr>
<tr><td>M3</td><td>The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.</td></tr>
<tr><td>M4</td><td>Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientise them to the injustice prevalent in society.</td></tr>
<tr><td>7</td><td>Name of the Degree</td><td colspan="2">Master of Science (M.Sc.,) in Physics</td></tr>
<tr><td>8</td><td>Name of the Department offering the program</td><td colspan="2">Physics</td></tr>
<tr><td>9</td><td>Vision of the Program</td><td colspan="2">“The Department of Physics strives to prepare the students for higher educational and career challenges by fostering scientific temper and human values”</td></tr>
</table>

10	Mission of the Program	"The Department of Physics is dedicated to inculcating in its students a deep commitment to the pursuit of knowledge and understanding in the Physical Sciences through promoting a spirit of open-ended intellectual curiosity. We encourage our students to be innovative and adaptable to new developments in society through an emphasis on quality in teaching, learning and research."	
11	Duration of the Program	2 years (Four semesters)	
12	Total No. of Credits	96	
13	Program Educational Objectives (PEOs)	PEO 1	Be a good samaritan and a responsible citizen of the world and use the powers vested in self due to logic of the subject to do good and protect the vulnerable in the world.
		PEO2	Should be able to enunciate Scientific Methodology to solve pervasive problems in the Society.
		PEO 3	Should be able to use Physics and Mathematics and Logic effectively in solving problems related to the Society.
		PEO4	Should be comfortable with Physics and explain the various technicalities of the subject to lay audience.

Programme Educational Objectives: PEOs are statements that describe Institution's Mission aligned with the programme 2-5 PEOs can be written.

- **Guidelines for the PEOs**
  - PEOs should be consistent with the mission of the Institution
  - The number of PEOs should be manageable
  - PEOs should be achievable by the program
  - PEOs should be specific to the program and not too broad

14	Graduation Attributes		The Following graduate attributes reflect the particular quality and feature or characteristics of an individual that are expected to be acquired by a graduate through studies at St. Joseph's University. · **Disciplinary knowledge** · **Communication Skills** · **Critical thinking** · **Problem solving** · **Analytical reasoning** · **Research-related skills** · **Cooperation/Teamwork** · **Reflective thinking** · **Information/digital literacy** · **Self-directed learning and Lifelong learner** · **Multicultural competence** · **Moral and ethical awareness/reasoning** · **Leadership readiness/qualities** · **International Outlook**
15	Program Outcomes (POs)	PO1	Ability to apply classical and quantum physics concepts to understand materials, biological and environmental topics.
		PO2	Ability to communicate with people on an official and outreach level about Physics and Physical Concepts.
		PO3	Ability to question the logic of an action and use reasonings related to physics, mathematics and logic to analyze the pros and cons and arrive at accepting or rejecting notions.
		PO4	Ability to use computers and technology to estimate and find solutions to Physics related problems and eliminating common human errors in such processes.

		PO5	Approach the future as a lifelong learner and provide leadership in society when required both for learning and for solving societal problems.

Programme Outcomes: POs are statements that describe what the students graduating from any of the educational Programmes should be able to do.

- **Guidelines for the POs**
  - Program outcomes basically describe **knowledge, skills and behavior** of students as they progress through the program as well as by the time of graduation.
  - POs should not be too broad
  - They must be aligned with the **Graduation Attributes**

Part B

M.Sc. Physics Curriculum

Courses and course completion requirements	No. of credits
Physics	92
Outreach activity	4

SUMMARY OF CREDITS

SEMESTER	**PAPER CODE AND TITLE**	**NO. OF TEACHING HOURS**	**NO. OF CREDITS**	**TOTAL MARKS**
SEMESTER I				
THEORY				
Paper I	**PH 7123:** Classical Mechanics	60	04	100
Paper II	**PH 7221:** Mathematical Physics	60	04	100
Paper III	**PH 7321:** Numerical Techniques	60	04	100
Paper IV	**PH 7421:** Experimental Physics - I	60	04	100
Paper V (**BC**)	**PHBC 7121**: Mathematical Preliminaries and Newtonian Mechanics	30	02	50
PRACTICAL				
Paper I	**PH 7P1:** Analog electronics	44	02	50

Paper II	**PH 7P2:** Numerical Techniques	44	02	50
Paper III	**PH 7P3:** Analytical Tools in Mathematical Physics - I	44	02	50
		TOTAL	**24**	**600**
SEMESTER II				
THEORY				
Paper I	**PH 8123:** Electrodynamics	60	04	100
Paper II	**PH 8221:** Experimental Physics - II	60	04	100
Paper III	**PH 8323:** Statistical Physics	60	04	100
Paper IV	**PH 8421:** Quantum Mechanics - I	60	04	100
Paper V **(BC)**	**PHBC 8121:** Modern Physics and Electricity	30	02	50
PRACTICAL				
Paper I	**PH 8P1:** General Physics	44	02	50
Paper II	**PH 8P2:** Digital Electronics	44	02	50
Paper III	**PH 8P3:** Analytical Tools in Mathematical Physics	44	02	50
		TOTAL	**24**	**600**
SEMESTER III				
THEORY				
Paper I	**PH 9121:** Quantum Mechanics - II	60	04	100
Paper II	**PH 9221:** Atomic and Molecular Physics	60	04	100

Paper III	**PH 9321:** Modern Optics	60	04	100
Paper IV	**PH 9423:** Advanced Physics	60	04	100
PRACTICAL				
Paper I	**PH 9P1:** Optics Lab	44	02	50
Paper II	**PH 9P2:** Mini Project	44	02	50
Paper-III	**PH 9P3:** Dissertation Project	88	04	100
		TOTAL	**24**	**600**
SEMESTER IV				
THEORY				
Paper I	**PH 0121:** Solid State Physics	60	04	100
Paper II	**PH 0221:** Nuclear and Particle Physics	60	04	100
Paper III-A (**DE**)	**PHDE 0420:** Astrophysics	60	04	100
Paper III-B (**DE**)	**PHDE 0522:** Materials Science	60		
PRACTICAL				
Paper I	**PH 0P1:**Applied Physics Lab	44	02	50
Paper II-A (DE)	**PH 0P2:** Astrophysics Lab	44	02	50
Paper II-B (DE)	**PH 0P3:** Material Science Lab			
Paper III	**PH 0P4:** Dissertation Project	88	04	100
		TOTAL	**20**	**500**

Total No. of Credits : 96 (92+4 Outreach)
KEY WORDS: DE – Departmental Elective and OE – Open Elective

CORE COURSES (CC)	
Course Title	Code Number
Classical Mechanics	**PH 7123**
Mathematical Physics	**PH 7221**
Quantum Mechanics - I	**PH 8421**
Quantum Mechanics - II	**PH 9121**
Statistical Physics	**PH 8323**
Electrodynamics	**PH 8123**

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number
Materials Science	**PHDE 0522**
Astrophysics	**PHDE 0420**

GENERIC ELECTIVE COURSES (GSE)/ Can include open electives offered	
Course Title	Code Number

SKILL ENHANCEMENT COURSE (SEC) – Any practical oriented and software based courses offered by departments to be listed below	
Course Title	Code Number
Numerical Techniques Lab	**PH 7P1**
Analytical Tools in Mathematical Physics - I	**PH 7P3**
Analytical Tools in Mathematical Physics - II	**PH 8P3**

VALUE ADDED COURSES (VAC) Certificate courses that add value to the core papers can be listed.	
Course Title	Code Number

Online courses offered or recommended by the department to be listed	
Course Title	Code Number

Course Outcomes and Course Content

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

SEMESTER-I

TOPICS TO BE COVERED:

THEORY PAPERS (4 CREDITS EACH):
1. **CLASSICAL MECHANICS**
2. **MATHEMATICAL PHYSICS**
3. **NUMERICAL TECHNIQUES**
4. **EXPERIMENTAL PHYSICS- I**

BRIDGE COURSE (2 CREDITS)
1. **MATHEMATICAL PRELIMINARIES AND MECHANICS**

LAB PAPERS (2 CREDITS EACH):
1. **ANALOG ELECTRONICS**
2. **NUMERICAL TECHNIQUES**

HYBRID COURSE: THEORY+LAB (2 CREDITS)
1. **ANALYTICAL TOOLS IN MATHEMATICAL PHYSICS I**

Semester	**1**
Title of the paper	**CLASSICAL MECHANICS - I**
Paper Code	**PH 7123**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

PH 7123 - CLASSICAL MECHANICS - I

Lagrangian formulation :
Mechanics of a particle+Problems, Mechanics of a system of particles+Problems, Constraints+Problems, Generalized coordinates+Problems, D'Alembert's principle+Problems, Lagrange's equations of motion+Problems, Simple applications of the Lagrangian formulation, Galilean invariance of Lagrange's equations 30hrs

Variational principle :
Hamilton's principle; Some techniques of the calculus of variations – applications – shortest distance problem, Brachistochrone; Derivation of Lagrange's equation from Hamilton's principle; Conservation theorems and symmetry properties – integrals of motion, cyclic coordinates, Jacobi's integral 8hrs

Central force :
Two body central force problem – Reduction to the equivalent one body problem; Equations of motion and first integrals; Classification of orbits; The Virial theorem; Differential equation for the orbit, integrable power-law potentials; The Kepler problem – inverse square law of force, motion in time in Kepler problem; Scattering and differential scattering cross-section 12hrs

Hamiltonian and Hamilton's Equations of Motion :
Legendre transformations, Hamiltonian Hamilton's equations of motion, Problems 10hrs

Reference Books :

1. Classical Mechanics by H.Goldstein, Narosa Publishing Home, New Delhi.
2. Classical Dynamics of Particles and Systems by Marion and Thornton, 5th Edition, Cengage
3. Classical Mechanics, John R. Taylor, University Science Books, 2005
4. Classical Mechanics by P.V.Panat, Narosa Publishing Home,, New Delhi.
5. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
5. Introduction to Classical Mechanics by R.G.Takwale and P.S.Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 7123 - CLASSICAL MECHANICS - I**

Mid Semester Examination

Part A: 3 Questions, Answer any 2, 8 Marks each

Part B: 4 Questions, Answer any 3, 3 Marks each

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Lagrangian formulation	30	36
	At the discretion of the instructor a minimum of 15 hours will be covered to make time for completing Bridge Course.	
Total marks excluding bonus questions		25
Total marks including bonus questions		36

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 7123 - CLASSICAL MECHANICS - I**

End Semester Examination:

Since this course contains a Bridge Course component, only the first 15 hours appear for mid-sem. 45 hours worth of material is after mid-sem.

Part A: 7 Questions, Answer any 5, 7 Marks each.

Part B: 4 Questions, Answer any 3, 5 Marks each.

Chapters included in mid semester exam gets a weight of 0.35 and the chapters in the second half of the semester achieves a weight of 0.65

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Lagrangian formulation	30	31
Variational principle	8	12
Central force	12	14
Hamiltonian formulation	10	12
Total marks excluding bonus questions		50
Total marks including bonus questions		69

Formula to calculate the maximum marks for each chapter (the marks have been adjusted to be either 7 or 5 or multiples and or sums of the same):

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter \times maximum\ marks\ (including\ marks\ for\ bonus\ questions) \times weightage \times 1.739}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Will be able to know and identify the forces of constraints within a system and work out its degrees of freedom
CO2	Understand	Will understand that the state of a system in classical mechanics is dependent on the equations of motion and that there will be as many equations of motion as the degrees of freedom.
CO2	Apply	Will be able to apply this knowledge and understanding to some standard systems: specifically to motion in a central force field.
CO3	Analyze	Will be able to abstract this and analyze symmetries in systems.
CO4	Evaluate	Will use the concepts learned to evaluate the effect of the above as the Principle of Least Action (and see it in other topics such as Optics and Theoretical Physics).
CO5	Create	Can use the knowledge gained by the above activities to write down the Hamiltonian of a given system.

The syllabus title must be as given below:
DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**MATHEMATICAL PHYSICS**
Paper Code	**PH 7221**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 7221 - MATHEMATICAL PHYSICS
(4 Credits - 4 Hours/Week)

Linear Algebra: Functions and continuous basis, Functional transformations, Closure condition and completeness, One-One correspondence to vector spaces 5 hrs

Complex analysis: Taylor and Laurent series, calculus of residues, contour integrations, introduction to analytic continuation and Riemann surfaces
12hrs

Fourier analysis: Fourier series, Fourier integral and transform, Dirac Delta Functions, convolution theorem, Parseval's identity,
10hrs

Special functions: Legendre, Laguerre and Hermite Functions, Bessel's function of 1st kind, spherical Bessel function, spherical harmonics generating function, recurrence relations,
15hrs

Tensors: Tensor Analysis, Pseudotensors and Dual Tensors, Tensors in General Coordinates, Jacobians 8 hrs

Differential Equations:

Partial Differential Equations: Helmholtz, Laplace, Poisson equations in all three coordinates, Separation of variables, Integral transforms**,** change of variables, method of characteristics, applications: wave, heat and diffusion equations 10 hrs

Reference Books :

1. Mathematical methods for Physicists - Arfken & Weber - 6 Edition-Academic Press- N.Y.
2. Mathematics for Physical Sciences - Mary Boas, John Wiley & Sons
3. Linear Algebra - Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill edition
4. Mathematical Methods of Physics - Mathews & Walker - 2 Edition- Pearson Edition
5. Mathematical Methods in Physics - Butkov Addison Wesley Publishers.
6. Advanced Engineering Mathematics, E. Kreyszig, 7 Edition, New Age International

7. Complex Variables and Applications - J.W.Brown, R.V.Churchill - (7 Edition)- Mc-Graw Hill - Ch. 2 to 7.
8. Complex Variables - Seymour Lipschutz
9. Fourier Series - Seymour Lipschutz, Schaum Outlines Series
10. Laplace Transform - Seymour Lipschutz, Schaum Outlines Series
11. Mathematics of Classical and Quantum Physics - Byron, Fuller Dover (1992)
12. Mathematical physics, applications and problems - V. Balakrishnan (2017)
13. Differential and Integral Calculus - N. Piskunov (1969)

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 7221 - MATHEMATICAL PHYSICS**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Linear algebra	5	10
Complex analysis	15	25
Fourier analysis	10	15
Special functions	12	20
Tensors	8	15
Differential Equations	10	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcome:

At the end of the course, the Student

CO1	Knowledge	Will learn the fundamental mathematical concepts used in physics.
CO2	Understand	Will understand the nuances of vector and tensor analysis, Functions of complex variables, Special Functions and Fourier Analysis.
CO2	Apply	Will be able to apply the various concepts like Legendre polynomial, Bessel functions and Hermite polynomials in Quantum Mechanics, Statistical Physics, Solid state physics, Modern Optics and Atomic Molecular Physics.
CO3	Analyze	Will be able to analyse various problems from physics and apply the concepts learnt in the class to effectively solve them.
CO4	Evaluate	Will be able to evaluate separation of variable technique to solve Laplace equation in different coordinate systems.
CO5	Create	Will be able to formulate, interpret and draw inferences from mathematical solutions and can visualize abstraction with the help of wx-maxima and other such tools.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**NUMERICAL TECHNIQUES**
Paper Code	**PH 7321**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 7321 - NUMERICAL TECHNIQUES

Interpolation and Curve fitting: Introduction to interpolation, Lagrange approximation, Linear interpolation. Problems

6 hrs

Numerical Differentiation and Integration: Approximating the derivative, numerical differentiation formulas, introduction to quadrature, trapezoidal and Simpson's rule, Applications.

10 hrs

Solutions of ODE: Initial value and boundary value problems, Euler's and Runge-Kutta Methods(up to second order)

6 hrs

Fourier Techniques: Fourier transforms, time series analysis, correlation, convolution applications of FT in various field.

8 hrs

Introduction to probability and statistical methods: Elementary statistical concepts and examples, random walk problem in one dimension, calculation of mean values for the random walk problem, probability distribution for large N, gaussian probability distributions, probability distribution involving several variables.

15 hrs

Statistical Inference: Model fitting and parameter estimation: Least square fits, Mean from least square fits, Multiparameter estimation, Goodness of fit, Confidence regions, Maximum Likelihood Methods:, Goodness of fit and confidence from maximum likelihood, Estimating parameter uncertainty, Hypothesis testing: Bayes Theorem, Updating the probability of a hypothesis, A priori distribution, Monte-Carlo Methods

15 hrs

Reference Books:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).

References:

3. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering, Prentice Hall of India (1998).
4. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
5. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in

C,
Cambridge (1998).
6. S. E.Koonin: *Computational Physics,* Benjamin/Cummings (Menlo Park, CA) 1986
7. R. Lupton: Statistics in Theory and Practice, Princeton University Press

Online texts :

Numerical Recipes online:http://library.lanl.gov/numerical/bookfpdf.html
P. Pacheco's User Guide to MPI:ftp://math.usfca.edu/pub/MPI/mpi.guide.ps
MPI online at
NERSC:http://www.nersc.gov/nusers/help/tutorials/mpi/intro/print.php
S. E.Koonin's Computational Physics Fortran codes:
http://www.computationalphysics.info
W. Krauth's Introduction to Monte Carlo:
http://www.lps.ens.fr/~krauth/budapest.pdf

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 7321 - NUMERICAL TECHNIQUES**

Chapter number	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Interpolation and curve fitting	6	10
Numerical Differentiation and Integration	10	15
Solution of ODE	6	10
Fourier Techniques	8	15
Probability and Statistics	15	25
Statistical Inference	15	25
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

PH 7320 – Semester 1- Numerical Techniques – course outcome chapter wise

Chapter	Learning outcomes
1. Interpolation and curve fitting	At the end of this chapter students will understand the importance of interpolation in problem solving and writing programs in python.
2. Numerical differentiation and integration	At the end of this chapter students will be able find the differentials and integrals of interpolating polynomials that are linear, exponential and trigonometric in nature and also apply the concepts of differentiation and integration in the real world with the help of the data given and also program it in python during the practical lab
3. Solutions of ODE	At the end of this chapter students will be able to solve differential equations and also write programs for them in python during practical lab.
4. Fourier techniques	At the end of this chapter students will acquire a knowledge on what Fourier technique is, how to convert functions from time domain to frequency domain, the students will also find their applications in solving problems in quantum mechanics in the second semester (free particle, momentum space and position space)
5. Introduction to probability and statistical methods 6. Statistical Inference	At the end of this chapter students will get a thorough understanding on how to solve problems in probability and statistics and also apply them in statistical real-world scenarios like elections, populations study etc, they will also apply them in quantum mechanics and statistical physics problem solving in their 2nd semester.
Overall Outcome: Applications	Applying the techniques learned in this unit to other activities is a major outcome of this course. Being able to fit a polynomial to data obtained in the lab experiments and obtaining confidence levels of the results in all semesters is one of the major outcomes. In addition, techniques learned in this are applied to other subjects like Classical Mechanics, Electrodynamics etc. to visualize the concepts learned therein.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**EXPERIMENTAL PHYSICS I**
Paper Code	**PH 7421**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 7421 - EXPERIMENTAL PHYSICS I

Error Analysis: Sources, propagation and analysis.

Transducers and Sensors: Characteristics - sensitivity, reproducibility, selecting a transducer and classification of transducers.
Transducers : Displacement: Resistive,capacitive and inductive. Signal conditioning using constant voltage potentiometric circuit.
Velocity: Linear velocity, Angular velocity: AC, DC and contactless tachometers.
Acceleration
Strain: Strain gauges: wire, metal foil and semiconductor type.
Temperature: RTD, thermistor and thermocouple
Pressure: Bellow, Bourdon tube and Diaphragm gauge. Diamond anvil cell for very high pressures. 20 Hrs

Measuring physical properties:

Thermal expansion: Interference, capacitance and LVDT methods. Thermal conductivity of good and poor conductors. Thermal diffusivity using periodic heating. Phase transitions using differential scanning calorimeter.
10Hrs

Electrical Properties:
Resistance: Two-probe and four-probe methods. DC and AC methods. High resistance by leakage.
Magnetic field: Search coil, Magnetoresistance- GMR and AMR and Hall probe methods
Magnetic susceptibility: AC susceptibility and Vibration sample magnetometer
10hrs

Signal Conditioning: Introduction, Block diagram of signal conditioning, review of op-amp basics, Integrator, differentiator using IC 741, Schmitt trigger, waveform generators. Practical differentiator, Practical integrator. Basic Instrumentation amplifier- important features, differential instrumentation amplifier using transducer Bridge, Logarithmic amplifier.
10 hrs

Data Acquisition And Conversion, Scalers And Counters: General data acquisition system (DAS), objective of DAS, Single-channel and multi-channel DAS block diagrams, Digital to Analog converter: R-2R ladder and binary-weighted ladder circuits. Analog to Digital converter- Flash and Successive approximation method,block diagram explanation,Scalers and Counters. 10 hrs

Reference Books:

1. Experimental Physics: R.A. Dunlap, Oxford University Press 1988
2. The Art of Experimental Physics, Dietz Preston, Eric S. Dietz, Barnes and Noble, 2001
3. An Introduction to Experimental Physics, Colin Cooke, London; UCL Press (Pennsylvania)
4. Introduction to nuclear science, Bryan J.C., Lavoisier Libraire 2008
5. Electronic Instrumentation and Measuring Techniques, W.D. Cooper, A.D. Helfrick 3rd Edition, PHI, 2000
6. A Course in Electrical, Electronics Measurement and Instrumentation, A.K. Sawhney, Dhanpat Rai & sons, 1996
7. Instrument transducers, Hermann KP Neubert, Second Edition, Oxford University Press, 1988.

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 7421 - EXPERIMENTAL PHYSICS I**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Transducers and Sensors	20	35
Measuring physical properties	20	35
Signal Conditioning	10	15
Data Acquisition And Conversion, Scalers And Counters	10	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{\textit{Number of teaching hours allotted for that chapter} \times \textit{maximum marks (including marks for bonus questions}}{\textit{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Will know the various parts of an electronic instrumentation system in detail and how a given physical change can be measured using it.
CO2	Understand	Would be able to understand how an instrumentation system works and what are the different kinds of errors that can affect the measurements made using this system and how to take care of these errors.
CO2	Apply	Would be able to apply this knowledge and understanding to choose appropriate transducers, signal conditioning and data acquisition systems from various available options to appropriately measure change in a given physical quantity.
CO3	Analyze	Would be able to analyze if the different systems chosen would work well with each other to achieve the required end result.
CO4	Evaluate	Will use the concepts learned to evaluate if the designed system fulfills the requirements of a good instrumentation system.
CO5	Create	Should be able to use the knowledge gained by the above activities to design their own instrumentation system that applies well to the problem in hand, taking care that the errors in measurement are within permissible limits.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**MATHEMATICAL PRELIMINARIES AND NEWTONIAN MECHANICS**
Paper Code	**PHBC 7121**
Number of teaching hours per week	**2**
Total number of teaching hours per semester	**30**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PHBC 7121 Mathematical Preliminaries and Mechanics
(2 Credits - 2 Hours/Week)

Vectors and vector spaces:

1. Vector Analysis: Review of basic properties, vector in 3-d spaces, differential vector operators, vector integration, curvilinear coordinates, Coordinate Transformations and Jacobians 5 hrs
2. Vector Spaces: Gram-Schmidt orthogonalization, self-adjoint operators, unitary operators, transformation of operators, vector spaces 3 hrs

Complex Analysis:
Analytic functions, Cauchy-Riemann conditions, Cauchy's theorem 3 hrs

Eigenvalue Problems:

1. Eigenvalue equations, matrix eigenvalue problems, hermitian eigenvalue problems, hermitian matrix diagonalization, normal matrices 4 hrs

Mechanics: Geometric representation of kinematic equations, Vectorial treatment of dynamics, Representative problems: (e.g. inclined plane, simple pendulum, Atwood machine, double pendulum, pendulum with a spring, etc.)

15 hrs

Reference Books :

1. R. S. Aggarwal, Senior Secondary Mathematics
2. Mathematics by R.D. Sharma, Dhanpat Rai Publications
3. A very short introduction to mathematics - Timothy Gowers, Oxford University press
4. Introduction to Classical Mechanics - Takwale, R.G. and Puranik, P.S., McGraw Hill (1978)
5. University Physics Vol. 1 - Young, Hugh D. and Freedman, Roger A., Pearson Education Limited (2016)
6. Concepts of Physics Vol. 1 - Verma, H.C., Bharati Bhavan (1992)
7. Principles of Physics - Halliday, D., Resnick, R. and Walker, J., Wiley (2015)
8. Classical Mechanics - Srinivasa Rao, K.N., University Press (2003)
9. Classical Mechanics - Kagali, B.A. and Shivalingaswamy T., Himalaya Publishing House (2008)

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper:

PHBC7121 - MATHEMATICAL PRELIMINARIES AND MECHANICS

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Vector Analysis	6	10
Vector Spaces	4	5
Eigenvalue Problems	5	10
Mechanics	15	25
Total marks excluding bonus questions		35
Total marks including bonus questions		50

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

The syllabus title must be as given below:
DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**Analog Electronics**
Paper Code	**PH7P1**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning out-come.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**Numerical Techniques Lab**
Paper Code	**PH7P2**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning out-come.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Labs for Semester I (4 Credits 8 Hours/Week)	
PH7P1 - Analog Electronics	**PH7P2-Numerical Techniques**
Op-amp inverting-non inverting and Summing amplifier	(Introduction to python-part I)
Integrator and Differentiator	(Introduction to python-part II)
Wien bridge oscillator	Linear Interpolation
Triangular wave generator	Lagrange Interpolation
Precision rectifier (Half and Full wave) Using OP27 and OP37	Numerical Differentiation and Nature of numerical errors
Schmitt trigger and difference amplifier	Trapezoidal Rule
Square wave generator	Simpson's 1/3 and 2/3 method
Design a circuit with real-time application using IC 741 and the concepts learnt in this lab.	Euler's Method for Solving Differential Equations
Phase Shift Oscillator	Runge Kutta Order 2 method with application to SHO problem
First-order low pass and high pass filter	Runge Kutta Order 4 method with application to SHO problem
Second-order low pass and high pass filter	Normal Distributions
Second-order Band Pass and Band Reject filters	Poisson Distributions
** Most of these experiments are done using IC 741	Fitting a Gaussian Function
	Fast Fourier Transform
	Monte Carlo Methods

The syllabus title must be as given below:
DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**Introduction to Analytical Tools for Mathematical Physics**
Paper Code	**PH 7P3**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning out-come.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Introduction to Analytical Tools for Mathematical Physics-I
(2 Credits, 4 Hours/Week)

1. Introduction to Computer Algebra System (CAS) Maxima — 8 hrs

2. Vector Spaces Using Maxima
    a. Bases, Components, Row and Column representations
    b. Plotting 3d vectors: plot3d, draw3d, vectr and draw packages
    c. matrix(), ctranspose(), sqrt(), ratsimp(), %i, %pi, unitvector(), realpart(), acos(), rootscontract()
    d. Linear Independence, orthogonality and Gram-schmidt
    e. Significance of Eigenvalues and Eigenvectors
    Gram-Schmidt Orthogonalization
    f. Equations and their roots in maxima
    g. Outer products, tensor products, closure condition — 32hrs

3. Repetition Lab — 4hrs

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**ELECTRODYNAMICS - I**
Paper Code	**PH 8123**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 8123 - CLASSICAL ELECTRODYNAMICS

Multipole expansions, Magnetostatics: Multipole expansions for a localized charge distribution in free space, problems. Magnetostatics-Divergence and curl of magnetic field and magnetic vector potential, its multipole expansion, Boundary conditions. 10 hrs

Fields in material media: static electric and magnetic fields in material media- polarization, magnetisation, concept of bound charges and currents and their physical interpretation, Gauss's and Ampere's law in material medium , Boundary conditions.

10 hrs

Time-varying fields: Time dependents fields, Faraday's law for stationary and moving media, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Maxwell's displacement current, Differential and Integral forms of Maxwell's equations, Maxwell's equations for material medium. 10 hrs

Energy, Force and Momentum relations in electromagnetic fields: Energy relations in quasi-stationary current systems, Poynting's theorem, General expression for electromagnetic energy, Conservation laws for momentum. 5 hrs

Electromagnetic wave equations: Electromagnetic wave equations, Electromagnetic plane waves in a stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth. 10 hrs

Inhomogeneous wave equations: Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator. Retarded Potentials-Jefimenko's equations, Lienard-Wiechert Potentials, Dipole radiation, Electric dipole radiation, point charge,Radiation energy and Radiation resistance. 15 hrs

Reference Books:

1. Introduction to Electrodynamics, (3 Edition) by David J.Griffith. Prentice-Hall of India, New Delhi
2. Introduction to Electrodynamics, by A.Z.Capri and P.V.Panat, Narosa Publishing House
3. Classical Electrodynamics by Hans C Ohanian, Prentice Hall
4. Classical electricity & Magnetism, by Panofsky and Phillips, Addison Wesley
5. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
6. Classical Electrodynamics, by J.D.Jackson, 3 Edition John Wiley.
7. Electromagnetic theory and Electrodynamics, by Satya Prakash, Kedar Nath and

co.Meerut.
8. Electromagnetics by B.B.Laud, Wiley Eastern.
9. Matrices and Tensors in Physics, A. W. Joshi, 3 Edition, New Age International
10. Modern Electrodynamics, Andrew Zangwill, Cambridge University Press (2013)
11. Electricity and Magnetism, Purcell, E.M., Morin, D.J., Cambridge University Press (2013)

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 8123 - CLASSICAL ELECTRODYNAMICS**

Mid Semester Examination:

Part A: 4 Questions, Answer any 3, 5 Marks each

Part B: 3 Questions, Answer any 2, 5 Marks each

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Multipole expansions, Magnetostatics	10	12
Fields in material media	10	13
	At the discretion of the instructor a minimum of 15 hours will be covered to make time for completing Bridge Course.	
Total marks excluding bonus questions		25
Total marks including bonus questions		36

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 8123 - CLASSICAL ELECTRODYNAMICS**

End Semester Examination

Since this course contains a Bridge Course component, only the first 15 hours appear for mid-sem. 45 hours worth of material is after mid-sem.

Part A: 7 Questions, Answer any 5, 7 Marks each.

Part B: 4 Questions, Answer any 3, 5 Marks each.

Chapters included in mid semester exam gets a weight of 0.35 and the chapters in the second half of the semester achieves a weight of 0.65

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Multipole expansions, Magnetostatics	10	7
Fields in material media	10	12
Time-varying fields	10	12
Energy, Force and Momentum relations in electromagnetic fields	5	7
Electromagnetic wave equations	10	12
Inhomogeneous wave equations	15	19
Total marks excluding bonus questions		50
Total marks including bonus questions		69

Formula to calculate the maximum marks for each chapter (the marks have been adjusted to be either 7 or 5 or multiples and or sums of the same):

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter \times maximum\ marks\ (including\ marks\ for\ bonus\ questions) \times weightage \times 1.739}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Outcomes

CO1	Knowledge	• Appreciation of various electric and magnetic interactions and the equations that govern them. (Gauss' Law, Biot-Savart, Maxwell's Equation etc) • Establishing Lorentz transformation equations and Special Relativity
CO2	Understand	• Insight into the empirical and theoretical formulae that describe Electrostatics and magnetostatics • Appreciating the similarities between electrostatics and magnetostatics
CO3	Apply and Analyze	• Will be able to use the concepts to effectively solve for fields and forces for arbitrary configurations of charges and currents • Ability to analyse the effect of motion on the electromagnetic fields
CO4	Evaluate	• Use the concepts to evaluate the nuances in the equations arrived from above. • Look into the possible limitations of the concepts (Electrostatic equations, Magnetostatic equations, radiation, Ideal multipoles etc)

CO5	Create	• Ability to create discrete charge and current configurations to satisfy given field conditions

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**EXPERIMENTAL PHYSICS-II**
Paper Code	**PH 8221**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 8221 - EXPERIMENTAL PHYSICS-II

Vacuum techniques: Vacuum hardware, gas flow regimes, pumping speed, conductance.
Pumps for producing vacuum: their classification - rotary vane, oil diffusion, turbomolecular, sputter-ion, cryopump.Getters – their characteristics and types.

10hrs

Vacuum measurement: Gauges for measuring low pressure – mechanical, thermal conductivity and ionization gauge- thermionic and penning.
Leak and leak detection, mass spectrometers. Some typical vacuum systems.

10hrs

Thin-film coating: Evaporative coating, Sputtering – Dynamics of glow discharge plasma, DC or plasma sputtering and AC sputtering, sputter yield. Laser ablation Technique. 10hrs

Techniques to measure the thickness of film and study surface profiles :
Transmission and Scanning Electron Microscopes and applications. Surface probe techniques: AFM, STM, MFM, their applications.

10hrs

Low-temperature techniques: Properties of cryogenic fluids, Cryogens and their applications - Liquid nitrogen, liquid hydrogen, Liquid Helium-I and II(phase diagram and thermodynamics of second-order phase transition), methods of producing low temperature- adiabatic expansion, Joule-Thomson throttling(JT) and Adiabatic Demagnetisation -thermodynamics of these processes; Liquefaction of Hydrogen and Helium using JT method, Bose-Einstein Condensate- laser cooling of atoms, Cryostat - bath and continuous flow cryostat; Cryocoolers- Stirling, Gifford McMahon and pulse tube type; Low-temperature measurement.

20 hrs

Reference Books:

1. Experimental Physics: R.A. Dunlap, Oxford University Press 1988
2. The Art of Experimental Physics, Dietz Preston, Eric S. Dietz, Barnes and Noble, 2001
3. An Introduction to Experimental Physics, Colin Cooke, London; UCL Press (Pennsylvania)
4.Material Science of Thin films, Milton Ohring, Second Edition2001, Academic press.
5.Electron microscopy and analysis, Peter J Goodhew, John Humphreys, Richard Beanland,
3rd edition, 2000.
6.Scanning probe Microscopy and Spectroscopy Theory and Applications, Second

Edition
Edited by Dan Bonnell, Wiley VCH, 2001.
7.Scanning Probe Microscopy–The Lab on a tip, Ernst Meyer, Hans J. Hug, Roland Bennewitz, Springer Verlag New York, 2003.
8.Cryogenics and Property Measurements at Low Temperatures, R.Srinivasan, A.K. Ray Chaudhari
and S. Kasturirangan, Allied Publishers.
9.Manual on the Experiments with IAS kit by R.Srinivasan.

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 8221 - EXPERIMENTAL PHYSICS-II**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Vacuum techniques	10	15
Vacuum measurement	10	15
Thin-film coating	10	15
Techniques to measure thickness of film and study surface profiles	10	15
Low-temperature techniques	20	40
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: **At the end of the Course, the Student**

CO1	Knowledge	Will know the various parts of a vacuum system, different thin films coating and characterization techniques and different techniques for attaining and maintaining low temperatures. And in tandem learn the behaviour of materials at low temperatures and vacuum conditions
CO2	Understand	Would be able to understand how different types of vacuum systems work, how thin films are coated and characterized and how a cryogenic system works. Will be able to understand vacuum system operation, vacuum components and their functions.
CO2	Apply	Would be able to apply this knowledge and understanding to choose and select components for preparation of appropriate vacuum systems for coating thin films or for designing a cryogenic system and various characterization techniques
CO3	Analyze	Would be able to analyze and carry out systematic troubleshooting of flaws in the designed systems like leak isolation etc and achieve the required design parameters
CO4	Evaluate	● Will use the concepts learned to evaluate if the designed system fulfills the requirements of a good system without any leaks and defects. ● Will be able to identify the role played by the major components of a typical vacuum system and predict how their operation affects the overall system performance
CO5	Create	Should be able to use the knowledge gained by the above activities to theoretically design their own vacuum system for a given thin film or cryogenic application with suitable feedback mechanism to identify if the designed system works well.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**STATISTICAL PHYSICS-I**
Paper Code	**PH 8323**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 8323 - STATISTICAL PHYSICS-I

Statistical Description of System of Particles: Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of the density of states, Liouville's theorem(Classical), Quasi-static processes, Problem Solving. 5hrs

Statistical Thermodynamics: Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems, Problem Solving. 9hrs

Classical Statistical Mechanics: Microcanonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation of a chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function, Problem Solving.
13hrs

Applications of Statistical Mechanics: Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal mono-atomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid. Maxwell velocity distribution, Related distributions and mean values, Problems Solving.
17hrs

Quantum Statistics of Ideal Gases: Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, The quantum mechanical paramagnetic susceptibility, Problem Solving 16hrs

Reference Books :

1. Fundamentals of Statistical and Thermal Physics, - F.Reif, McGraw - Hill, International Edition (1985)
2. Statistical Mechanics, R.K.Pathria and Paul D. Beale, Academic Press Inc. (4th Edition)
3. Statistical Mechanics, K.Huang, John Willey & Sons (2 Edition)

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 8323 - STATISTICAL PHYSICS - I**

Mid Semester Examination

Part A: 3 Questions, Answer any 2, 8 Marks each

Part B: 4 Questions, Answer any 3, 3 Marks each

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Statistical Description of System of Particles	5	9
Statistical Thermodynamics	9	11
Classical Statistical Mechanics	13	16
Total marks excluding bonus questions		25
Total marks including bonus questions		36

<u>MODEL BLUEPRINT</u>

<u>(Part of the syllabus)</u>

Code number and Title of the paper: **PH 8323 - STATISTICAL PHYSICS-I**

End Semester Examination

Part A: 7 Questions, Answer any 5, 7 Marks each.

Part B: 4 Questions, Answer any 3, 5 Marks each.

Chapters included in mid semester exam gets a weight of 0.35 and the chapters in the second half of the semester achieves a weight of 0.65

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Statistical Description of System of Particles	5	5
Statistical Thermodynamics	9	7
Classical Statistical Mechanics	13	12
Applications of Statistical Mechanics	17	23
Quantum Statistics of Ideal Gases	16	22
Total marks excluding bonus questions		50
Total marks including bonus questions		69

Formula to calculate the maximum marks for each chapter (the marks have been adjusted to be either 7 or 5 or multiples and or sums of the same):

$$\frac{\text{Number of teaching hours allotted for that chapter} \times \text{maximum marks (including marks for bonus questions)} \times \text{weightage} \times 2}{\text{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Will be able to appreciate that computation of the state of a macroscopic system made up of many particles will be akin to computing the probability of obtaining a certain configuration in a game of as many dice with many more sides than the usual die.
CO2	Understand	Will understand that the total possible states of a system is related to the partition function of a system.
CO2	Apply	Will be able to apply this knowledge and understanding to the three main thermodynamic ensembles and obtain the equations relating the macroscopic thermodynamic quantities to microscopic properties. These can then be applied in other subjects like Solid State Physics, Material Science and Condensed Matter Physics.
CO3	Analyze	Will be able to, using the above concepts, analyze the Bose-Einstein and Fermi-Dirac Statistics and show that Maxwell-Boltzmann statistics is obtained as a classical limit from both the above statistical distributions. Will be able to analyze the properties of a system with a few numbers of particles embedded in a thermal bath.
CO4	Evaluate	Will use the concepts learned to evaluate the effect of the above on ideal systems containing Bosons and Fermions.
CO5	Create	Will be able to create models of systems that will find a wide variety of applications in other subjects like Solid State Physics, Material Science and Condensed Matter Physics and even interdisciplinary fields like Chemical Physics and Biophysics.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**QUANTUM MECHANICS - I**
Paper Code	**PH 8421**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 8421 - QUANTUM MECHANICS - I

One Dimensional Problem:

Particle in a box problem: Particle in an infinite potential as a prototypical problem in quantum mechanics: Energy Eigenvalues, Momentum Wave Function. Momentum and position expectation values in Momentum space.
Finite wells and barriers, Tunnelling effect.
Simple Harmonic Oscillator: Analytical Method

10 hrs

Postulates of quantum mechanics: Representation of states and dynamical variables, observables, self-adjoint operators, eigenfunctions and eigenvalues, degeneracy, Dirac delta function, Completeness and closure property, Physical interpretation of eigenvalues, eigenfunctions and expansion coefficients, eigenvalues and eigenfunctions of the momentum operator. Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators generalized uncertainty principle using Schwarz inequality, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigenvalues and eigenfunctions of a simple harmonic oscillator by operator method. Ehrenfest Theorem

15hrs

Time Evolution of a system: Constants of motion, Schrodinger and Heisenberg picture

3hrs

Quantum Mechanics in Two and three Dimensions
Particle in a 2-D box as an example. Degeneracies.
Separation of variables, angular equation, spherical harmonics, orthogonalization; radial equation, Hydrogen Atom Problem: Radial Solutions (Associated Laguerre functions included).

14 hrs

Angular Momentum: Angular momentum equations - separation of variables. Associated Legendre equations. L^2 operator; eigenvalues and eigenfunctions of L^2 and Lz operators, ladder operators L_+ and L_-, Pauli theory of spins(Pauli's matrices), angular momentum as a generator of infinitesimal rotations, matrix representation of J in |jm> basis. Addition of angular momenta, Computation of Clebsch-Gordan coefficients in simple cases (J1=1/2, J2=1/2). 18hrs

Reference books:

1. Concepts of Modern Physics - A. Beiser
2. Introduction to Quantum Mechanics by David J.Griffiths
3. Introduction to Quantum Physics by Claud Cohen-Tannoudji, Bernard Diu, Frank

Laloe, 3rd Edition, Herman and John Weily, Ltd.

4. Introductory Quantum mechanics by Granier, Springer Publication.
5. Introductory Quantum Mechanics, Liboff, 4 Edition, Pearson Education Ltd.
6. A Text-book of Quantum Mechanics by P.M.Mathews and K.Venkatesan.
7. Modern Quantum mechanics by J.J.Sakurai
8. Quantum Physics by R. Eisberg and R.Resnick
9. Quantum Mechanics by L.I.Schiff
10. Quantum mechanics by A.Ghatak and S.Lokanathan
11. Quantum Mechanics: Concepts and Applications by Nouredine Zettili, Wiley (2009)
12. Quantum Mechanics I: The Fundamentals by S. Rajasekar and R. Velusamy, CRC Press, Taylor and Francis Group (2015)

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 8421 - QUANTUM MECHANICS - I**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
One dimensional problem	14	20
Postulates of quantum mechanics	15	25
Time Evolution	3	5
Quantum Mechanics in two dimensions	2	5
Quantum Mechanics in Three Dimensions	2	5
Hydrogen Atom Problem: Radial Solution	6	10
Angular Momentum	18	30
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{\text{Number of teaching hours allotted for that chapter} \times \text{maximum marks (including marks for bonus questions}}{\text{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Will know that there exists a fundamental property at the microscopic level called the uncertainty principle that requires a non-classical method to understand physical systems (at the microscopic level). This will necessitate describing the state of the system using a wavefunction. Will know that there is no `zero' energy state in quantum mechanics.
CO2	Understand	Will understand that the wavefunctions are solutions to the Schrodinger Equation. Will also understand that symmetries in the system at higher dimensions than one, will lead to degenerate solutions.
CO2	Apply	Will apply this to several systems described by their potentials (like the one dimensional infinite potential, one dimensional simple harmonic oscillator and three dimensional hydrogen atom problem). Application in STM and Quantum Nano Structures.
CO3	Analyze	Will be able to analyze all these systems using the concepts of linear algebra and the quantum mechanical postulates.
CO4	Evaluate	Will be able to interpret the consistency of the wavefunctions and energy levels evaluated for the various systems in terms of the uncertainty principle.
CO5	Create	Will be able to create a consistent view of the quantum mechanical results with those of classical physics in the continuum limit using the correspondence principle for each of the systems analyzed.

The syllabus title must be as given below:
DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**MODERN PHYSICS AND ELECTRICITY**
Paper Code	**PHBC 8121**
Number of teaching hours per week	**2**
Total number of teaching hours per semester	**30**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PHBC 8121 Modern Physics and Electricity

(2 Credits - 2 Hours/Week)

Modern Physics

Inadequacy of Classical Physics

Particle properties of waves: Electromagnetic waves, UV Catastrophe, Black body radiation, Photoelectric effect, Compton effect derivation and problem solving.
Wave properties of particles: De Broglie waves, Phase and group velocities (derivation), particle in a box, Heisenberg's Uncertainty principle.

5 hrs

Quantum Mechanics The wave equation, wave packet, wave function and normalising a wave function, Schrodinger's equation: time-dependent and independent form, Linearity and superposition, Expectation values, operators.

3 hrs

Free Particle Problem: Wavefunction, normalization, Fourier form, Fourier components as amplitude, momentum wave function, time derivative and position derivative and diffusion equation

7 hrs

Electricity

Vector Analysis Revision:

Vector Algebra, Differential Calculus - Gradient, Divergence and Curl, Integral Calculus - Fundamental theorem of Gradient, Divergence and Curl, Curvilinear Coordinates - Spherical polar and Cylindrical

5 hrs

Electrostatics:

Electric field, Coulomb's law, field lines, flux, Gauss's law and its applications, Electric potential- Poisson's and Laplace's equations, Boundary value problems, Conductors-basic properties, induced charges-volume and surface and capacitors.

10 Hrs

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PHBC8121 - MODERN PHYSICS AND ELECTRICITY**

Title	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Inadequacies of classical physics	5	5
Quantum Mechanics	3	5
Particle in a box problem	7	10
Vector Analysis Revision	5	10
Electrostatics	10	15
Total marks excluding bonus questions		35
Total marks including bonus questions		50

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**General Physics Lab**
Paper Code	**PH8P1**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**Digital Electronics Lab**
Paper Code	**PH8P2**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Labs for Semester II (4 Credits 8 Hours/Week)	
PH8P1 - General Physics	**PH8P2 Digital Electronics**
e/m by Helium Arc Method	RS flip flop and decade counter
Stefan's constant	Astable and monostable multivibrator
Thermal relaxation of bulb	DAC: Weighted resistors and R-2R network
Cu-Constantan Thermocouple and Si diode	Amplitude Modulation and demodulation
Milikan Oil drop experiment	Frequency Modulation and demodulation
High resistance by leakage	Pulse amplitude modulation and demodulation
LVDT and Strain Gauge	ADC – IC 0804
AC bridges	Multiplexer and demultiplexer
Absorption spectrum of copper sulphate	Voltage-controlled oscillator: IC 555 and phase Lock Loop IC 565
Rigidity Modulus of Brass	Frequency multiplication
Verification of Beer Lambert's Law-Study of Intensity variation from different concentration dyes using Spectrophotometer Absorption (cross-section)	DAC – IC 1408
Dielectric Constant of CCl4	Design a circuit with a real-world application using the concepts learnt in this lab.
The arc atomic spectrum of Iron (Fe-I)	

The syllabus title must be as given below:
DEPARTMENT OF PHYSICS

Semester	**1**
Title of the paper	**Introduction to Analytical Tools for Mathematical Physics-II**
Paper Code	**PH8P3**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Introduction to Analytical Tools for Mathematical Physics-II (2 Credits, 4 Hours/Week)
1. Complex variables using Maxima a. Meaning of analyticity and Plotting a complex function in maxima b. Contour plots of functions in maxima c. Convergence of series using maxima-Laurent and Taylor d. Finding the poles (Simple and multipole) e. Residues of complex functions using maxima f. Cauchy Integral Theorem and formula 24hrs
2. Integrals in Maxima 8hrs
3. Fourier Analysis: a. Fourier series in maxima 4hrs
4. Special functions in maxima a. Comparing Bessel function series to built-in Bessel functions b. Built-in functions: Hermite, Legendre, Laguerre 8hrs

SEMESTER-III

TOPICS TO BE COVERED:

THEORY PAPERS (4 CREDITS EACH):

1. **QUANTUM MECHANICS-II**
2. **ATOMIC AND MOLECULAR PHYSICS**
3. **MODERN OPTICS**
4. **ADVANCED PHYSICS (to be offered from 2024)**
5. **FOUNDATIONS OF MATERIAL SCIENCE AND ASTROPHYSICS (to be offered in 2023 and discontinued in 2024)**

LAB PAPERS (2 CREDITS EACH):

1. **OPTICS**
2. **MINI PROJECT**

DISSERTATION PROJECT (4 CREDITS)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**QUANTUM MECHANICS - II**
Paper Code	**PH 9120**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 9120 - QUANTUM MECHANICS - II

Symmetry in Quantum Mechanics: Symmetry Parity, Identical particles, symmetric and antisymmetric wave functions, Slater determinant, collision of identical particles, spin functions for systems with more than one electron.

10 hrs

Approximation Methods :

1. Variational method: Basic principles and applications to a particle in a box, SHO, hydrogen atom. 5 hrs
2. WKB approximation: Qualitative development and condition for the validity of this approx., Bohr's quantization condition, applications to tunneling such as a-particle, field emission. 5 hrs
3. Time-independent Perturbation theory: Non-degenerate and degenerate cases (up to second-order).
   a. Applications: Stark effect,
   b. Applications: Anharmonic oscillator
   c. Applications: Zeeman effect

15 hrs

4. Time-dependent Perturbation theory: Transition amplitude 1 and 2 order, selection rules, constant perturbation(1st order). Fermi's golden rule, Harmonic perturbation, Interaction of atom with em radiation, dipole approx. Einstein coefficient for spontaneous emission 10 hrs

Theory of Scattering: i) Kinematics: Differential and total cross sections, scattering amplitudes using Green's function scattering by symmetric potential, mutual scattering of two particles, Centre of Mass frame, Laboratory frame.

ii) Dynamics - a) Born approximation, Validity of Born Approx., Application to square well potential, screened coulomb and Yukawa potential. b) Partial wave analysis, phase shift, scattering amplitudes in terms of phase shift, optical theorem, scattering by a square well potential and perfectly rigid sphere.

15hrs

Reference Books :

1. Introduction to Quantum Physics by Claud Cohen-Tannoudji, Bernard Diu, Frank Laloe, 3rd Edition, Herman and John Weily, Ltd.
2. Introduction to quantum mechanics by D.I.Griffiths (Pearson Education)(II Edition)
3. Quantum Mechanics Concepts and Applications, Nouredine Zettili, Wiley
4. A Textbook of Quantum Mechanics, P.M.Mathews and K.Venkatesan, Tata McGraw Hill
5. Modern Quantum Mechanics by J.J.Sakurai
6. Quantum Mechanics by L.I.Schiff, McGraw Hill
7. Quantum Physics by R.Eisberg and R.Resnick(Wiley and Sons)
8. Quantum Mechanics by A.Ghatak and S.Lokanathan, Macmillan India Ltd.
9. Quantum Mechanics, G. Aruldhas

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 9121 - QUANTUM MECHANICS - II**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Symmetry in Quantum Mechanics	10	15
Variational method	5	10
WKB approximation	5	10
Time-independent Perturbation theory	15	25
Time-dependent Perturbation theory	10	15
Scattering	15	25
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{\text{Number of teaching hours allotted for that chapter} \times \text{maximum marks (including marks for bonus questions}}{\text{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student will be able to

CO1	Knowledge	Know how Quantum Mechanical calculations are probabilistic in nature and yet see that it can provide reasonable estimates to experimentally measurable quantities.
CO2	Understand	Understand that Quantum Mechanical systems have discrete states that are solutions of the Schrodinger equation and that one or more of these states have corresponding energies that are discrete too.
CO2	Apply	Apply the concepts learned in Quantum Mechanics I to more realistic situations and see how concepts like Linear Algebra and the Postulates of Quantum Mechanics pan out to such systems.
CO3	Analyze	Analyze the validity of various approximation methods in Quantum Mechanics
CO4	Evaluate	Obtain bounds on the ground state energies of systems using the Variational Method; estimate transition probabilities in quantum systems using Einstein Coefficients.
CO5	Create	Construct mental models of Quantum Systems - particularly that of Transitions of One electron systems and calculate the energies and construct eigenstates of systems of indistinguishable particles.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**ATOMIC AND MOLECULAR PHYSICS**
Paper Code	**PH9222**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted).

PH9222 - ATOMIC AND MOLECULAR PHYSICS

Unit:1 Atoms

Electromagnetic spectrum, Types of molecular energies, Hyperfine structure, Width of a spectral line, Nuclear spin, Normal and anomalous Zeeman effect, Paschen - Back effect. Lamb Shift, Schrodinger Wave equation for a two-electron system, many-electron atoms: LS and JJ coupling schemes, Lande interval rule.

(13 hours)

Unit II: Rotational, vibrational and electronic spectroscopy

Rotational and Vibrational spectra for diatomic molecules, Electronic spectra of diatomic Molecule, Vibrational coarse structure, Vibrational analysis of band system, Frank-Condon principle, Dissociation energy & dissociation products, Rotational fine structure of electronic vibrational transitions, Electronic angular momentum in diatomic molecule.

(15 hours)

Unit III: Optical and Raman Spectroscopy

Optical Spectroscopy: Ultraviolet and visible Spectroscopy: UV visible Spectrophotometers - Measurement of Absorption, transmittance and reflections, Fluorescence and Phosphorescence: Measurement of Fluorescence – Spectrofluorometer, Photoluminescence: light-matter interaction, Time-Resolved spectroscopy.

Raman Spectroscopy: Quantum Theory of Raman Effect- Classical Theory- Molecular Polarizability-Rotational Raman Spectra-Vibrational Raman Spectra- Experimental techniques of Raman spectroscopy – Molecular structural studies.

(15 hours)

Unit IV: Resonance spectroscopy

NMR Spectroscopy: Nuclear spin magnetic moment, Interaction of nuclear magnet with an external magnetic field, NMR spectrometer, chemical shift, spin-spin coupling splitting of NMR signals, Applications.

ESR Spectroscopy: Electron spin interaction with an external magnetic field, Simple ESR Spectrometer, ESR spectrum, Applications

Nuclear Quadrupole Resonance: Electric field gradient, the principle of NQR, transitions for axially symmetric and non-symmetric systems, NQR instrumentation, Applications.

(17 hours)

Reference books:

1. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York Recent edition.
2. Molecular structure & spectroscopy, G.Aruldhas; Prentice - Hall of India, New Delhi(2001)
3. Fundamentals of molecular spectroscopy, Colin N.Banwell & Elaine M.McCash, Tata McGraw -Hill publishing company limited, Fourth edition(2002).
4. Solid State Physics, A.J.Dekker, Macmillan India Ltd. (2005)
5. Quantum Physics of atoms, molecules, solids nuclei & particles, Robert Eisberg, Robert
6. Resnick, Second edition, John Wiley & Sons (Asia) Ltd. (1985)
7. Solid State Physics, Charles Kittel, John Willey & sons
8. Material Science & Engineering, V.Raghavan, Prentice -Hall of India, New Delhi (2001)
9. Spectroscopy – Straughan Walker, McGraw-Hill, New York
10. Introduction to Atomic Spectra, Harvey Elliot White. McGraw-Hill, 1934

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 9222 - ATOMIC AND MOLECULAR PHYSICS**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Unit I: Atoms	13	20
Unit II: Rotational, vibrational and electronic spectroscopy	15	25
Unit III: Optical and Raman Spectroscopy	15	25
Unit IV: Resonance spectroscopy	17	30
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student will be able

CO1	Knowledge	To impart knowledge about the physical and chemical properties of matter through spectroscopy. To impart knowledge about the physics of electron and nuclei spin by using advanced spectroscopic techniques like NMR, ESR and NQR with low energy electromagnetic waves.
CO2	Understand	To understand the fundamentals of spectroscopy and the atomic spectra of hydrogen atoms.
CO2	Apply	To apply and determine the structure of molecules using spectroscopic techniques. How to apply quantum mechanical principles to solve problems in atomic physics
CO3	Analyze	To illustrate properties of matter by analysis and interpretation of spectral data from molecular and material science research To analyze the structural properties of solids using an X-ray diffraction pattern
CO4	Evaluate	To identify the best method to solve the given spectroscopic problems.
CO5	Create	Create a picture of the structure of molecules using spectroscopy techniques.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**MODERN OPTICS**
Paper Code	**PH 9320**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PH 9320 - MODERN OPTICS

Geometric optics: Fermat's principle and applications to laws of reflection and refraction. Paraxial optics, ABCD matrix description of lenses, mirrors, etc.

phase and group velocity, material dispersion, normal and anomalous dispersion, chromatic aberration

10 hrs

Fourier techniques and Diffraction theory of image formation: Fourier analysis, Fourier transforms, diffraction of light, Kirchoff's scalar diffraction theory. Fourier transformation by propagation, lenses and their description in Fourier transformation and imaging. Spread functions, modulation transfer functions, convolution, etc.Optical data processing

20hrs

Coherence theory: Coherence, classical coherence functions, autocorrelation function and time coherence. Spatial coherence, mutual coherence functions, visibility of fringes.

10hrs

Crystal optics: Double refraction, Polarization and anisotropy of wave propagation in crystals, Retarders- Quarter wave and Half-wave plates, variable retarder, uniaxial and biaxial crystals

10hrs

Non-linear Optics: Physical origin of non-linear polarization, electromagnetic wave propagation in non-linear media, optical second harmonic generation, optical mixing, third-harmonic generation, self-focusing of light, parametric generation of light.

10hrs

Reference Books:

1. Max Born and Emil Wolfe, Principles of Optics, Pergamon Press, 6th Edition (1985).
2. M.V. Klein and T.E. Furtak, Optics, 2nd edition, John Wiley (1986).
3. R.S. Sirohi, Wave Optics and Applications, Orient Longman (1992)
4. A.K. Ghatak and K. Thyagarajan, Contemporary Optics, Plenum Pub. Co. (1978).
5. J.R. Mayer-Arendt M.D. Introduction to Classical and Modern Optics, 2nd Edition, Prentice Hall (1988).
6. R.S. Sirohi and M.P. Kothiyal, Optical Components, Systems and Measurement Techniques, Marcell Dekker (1991).
7. R.D Guenther, Modern Optics, John Wiley (1990)
8. P. Hariharan, Optical Holography, Cambridge University Press (1984).
9. Ghatak, A. K, Modern Optics,

10. D. Casasent, (ed), Optical Data Processing, Springer Verlag (1978).

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PH 9320 - MODERN OPTICS**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Geometric optics+Dispersion	10	20
Fourier techniques and Diffraction theory of image formation	20	35
Coherence theory	10	15
Crystal optics	10	15
Non-linear Optics	10	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	To impart knowledge about the various tools used in analyzing and simplifying different optical systems.
CO2	Understand	To understand how different material media respond differently to the incident visible light and exhibit different material properties.
CO2	Apply	To apply the concepts learned in this course for understanding the propagation of light through different optical systems.
CO3	Analyze	To analyze the optical properties of different materials and relate them to their molecular structure.
CO4	Evaluate	To evaluate the optical systems using the various mathematical tools learnt in this course.
CO5	Create	To theoretically create optical devices like a stable laser cavity or an interferometer based on the knowledge gained in this course for specific optical applications To create an experiment to analyze a specific optical property of a material.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**3**
Title of the paper	**ADVANCED PHYSICS**
Paper Code	**PH 9423** (to be introduced in 2024)
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

PH 9423 - ADVANCED PHYSICS
(to be introduced from 2024)

Hamiltonian Formalism:

Hamiltonian formulation:
Canonical variables; Cyclic coordinates and conservation theorems in Hamiltonian formulation; Derivation of Hamilton's equations from a variational principle; Canonical transformations – Generating functions, examples; Poisson brackets and other canonical invariants; Equations of motion and conservation theorems in Poisson bracket formulation; Phase-space; Liouville's theorem 15hrs

Hamilton-Jacobi Theory:
Hamilton's Principal Function, Harmonic Oscillator Problem, Separation of Variables, Central Force Problem, Action-angle variables, Problems. 15 hrs

Ideal Quantum Systems:

Ideal Bose System: Photon gas - i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity. Einstein derivation of Planck's law, Bose-Einstein Condensation, Specific heat, Photon gas - Einstein and Debye's model of solids, Problems 7hrs

Ideal Fermi System: Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Electronic specific heat, White - Dwarfs, Compressibility of Fermi gas, Pouli's paramagnetism, A relativistic degenerate electron gas, Problems 8hrs

Relativistic Electrodynamics

Relativistic Kinematics: Experimental basis for the special theory of relativity (Michelson - Morley experiment), Lorentz transformations, time dilation, length contraction and relativity of Simultaneity, Relativistic velocity addition. 5hrs

Covariance and Relativistic Mechanics: Minkowski's space-time diagram, light cone, Four vectors, Lorentz transformation of Four vectors, Relativistic energy, momentum, Minkowski's force. 5hrs

Covariant formulation of electrodynamics: Magnetism as a relativistic phenomenon, Transformation of electric and magnetic fields and Lorentz force in relativistic domain, Electromagnetic field tensor. 5hrs

Reference Books :

1. Classical Mechanics by H.Goldstein, Narosa Publishing Home, New Delhi.
2. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
3. Mechanics by L.D. Landau and E.M. Lifshitz, Elsevier
4. Lagrangian and Hamiltonian Mechanics by M.G. Calkin, World Scientific
5. Fundamentals of Statistical and Thermal Physics, - F.Reif, McGraw - Hill, International Edition (1985)
6. Statistical Mechanics, R.K.Pathria and Paul D. Beale, Academic Press Inc. (4th Edition)
7. Statistical Mechanics, K.Huang, John Willey & Sons (2 Edition)

8. Introduction to Electrodynamics, (3 Edition) by David J.Griffith. Prentice-Hall of India, New Delhi
9. Special Theory of Relativity, by Robert Resnick.
10. Classical Electrodynamics, by J.D.Jackson, 3 Edition John Wiley.
11. Classical Theory of Fields by L.D. Landau and E.M. Lifshitz, Elsevier

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 9423 - ADVANCED PHYSICS**

Mid Semester Examination

Part A: 3 Questions, Answer any 2, 8 Marks each

Part B: 4 Questions, Answer any 3, 3 Marks each

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Hamiltonian formulation	15	19
Ideal Bose System	7	11
Relativistic Kinematics	5	6
Total marks excluding bonus questions		25
Total marks including bonus questions		36

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 9423 - ADVANCED PHYSICS**

End Semester Examination

Part A: 7 Questions, Answer any 5, 7 Marks each.

Part B: 4 Questions, Answer any 3, 5 Marks each

Chapters included in mid semester exam gets a weight of 0.35 and the chapters in the second half of the semester achieves a weight of 0.65

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Hamiltonian formulation	15	12
Hamilton-Jacobi Theory	15	21
Ideal Bose System	7	5
Ideal Fermi System	8	12
Relativistic Kinematics	5	5
Covariance and Relativistic Mechanics	5	7
Covariant formulation of electrodynamics	5	7
Total marks excluding bonus questions		50
Total marks including bonus questions		69

Formula to calculate the maximum marks for each chapter (the marks have been adjusted to be either 7 or 5 or multiples and or sums of the same):

$$\frac{\text{Number of teaching hours allotted for that chapter} \times \text{maximum marks (including marks for bonus questions)} \times \text{weightage} \times 2}{\text{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Will be able to know and identify the roles of symmetry in classical mechanics, quantum mechanical effects in statistical systems and relativity in electrodynamics
CO2	Understand	Will understand how symmetry simplifies the Hamiltonian Formulation, that the classical systems previously encountered are special cases of much more general systems.
CO2	Apply	Will be able to apply this knowledge of symmetry and quantum statistical physics to evaluate general properties of systems.
CO3	Analyze	Will be able to abstract this and analyze symmetries in systems.
CO4	Evaluate	Will use the concepts learned to evaluate theoretical systems.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**Optics Lab**
Paper Code	**PH9P1**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**Mini Project**
Paper Code	**PH9P2**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**III**
Title of the paper	**Dissertation Project**
Paper Code	**PH9P3**
Number of teaching hours per week	**8**
Total number of teaching hours per semester	**100**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Labs for Semester III (2 Credits 4 Hours/Week)	
PH9P1 - Optics	**PH9P2 - Mini Project**
Ultrasonic interferometer	Students' choice of project
Michelson interferometer to determine the wavelength separation between Sodium D1 and D2 lines.	
Size of Lycopodium particles or White blood cells and thickness of wire or hair strand using diffraction	
The wavelength of a laser using diffraction grating- single and double slit	
Fabry Perot Interferometer	
Refractive Index of Glass and wavelength of light using Michelson Interferometer	
Determine birefringence of Mica sheet using Babinet's Compensator	
Cornu's Fringes and Determination of Young's modulus of a given material	
Zeeman effect	
The thickness of Mica using Edser Butler Method	
Ultrasonic diffraction	
Linear coefficient of thermal expansion by single slit diffraction	
Design your own experiment using the resources available in the optics lab.	
Refractive index of liquid mixture (Water / Ethanol)	
Laser properties experiment : Coherence	

Labs for Semester III (4 Credits 8 Hours/Week)
PH9P3 - Dissertation Project
Students’ Choice of supervisors; weekly internal progress review (2-3 hrs)

Guidelines for Mini Project:

1. The projects are expected to be of master’s level. E.g . Building a frequency generator, an RF transmitter and receiver, a Van De Graff generator etc.
2. The project should have a quantitative outcome which is some measurable physical quantity.
3. The final version of the project should be in an independent, compact, robust form with no loose wires hanging out.
4. The output obtained should be consistently repeatable.
5. There are a total of 11 work weeks. The time-line should be chalked out latest by the third session.
6. All attempts should be made to keep the cost of the project minimal.
7. If the project results in an instrument that can be of use in the lab then extra points would be awarded.

Setting up a Workshop to have hands-on training in drilling, lathe, glass blowing etc.,

SEMESTER-IV

TOPICS TO BE COVERED:

THEORY PAPERS (4 CREDITS EACH):

1. **SOLID STATE PHYSICS**
2. **NUCLEAR AND PARTICLE PHYSICS**

DEPARTMENT ELECTIVE (4 CREDITS):

1. **ASTROPHYSICS**
2. **MATERIAL SCIENCE**

LAB PAPERS (2 CREDITS EACH):

1. **APPLIED PHYSICS LAB**
2. **ELECTIVE (ASTROPHYSICS/MATERIAL SCIENCE)**

DISSERTATION PROJECT (4 CREDITS)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**SOLID STATE PHYSICS**
Paper Code	**PH0122**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted).

PH0122 - SOLID STATE PHYSICS

Crystal physics: Symmetry operations; Bravais lattices; Point and space groups; Miller indices and reciprocal lattice; X-ray diffraction: Laue theory of X-ray, Geometrical structure factor, Atomic scattering factor, calculations for bcc, fcc & diamond structure, Crystal binding; Defects in crystals; Point and line defects.

10hrs

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators.
10hrs

Electronic properties: Free electron theory of metals; electrons in a periodic potential; Bloch equation; Kronig-Penny model; band theory; metal, semiconductor and insulators; band-gap, intrinsic and extrinsic semiconductors, Hall Effect, p-n junction. 10hrs

Dielectrics: Polarizability, microscopic concepts of polarisation, the internal field in solids, Clausius-Mossotti relation; Dielectric constant - static dielectric constant of solids; dipole theory of ferroelectricity, antiferroelectricity; piezoelectricity.

10hrs

Magnetism: Quantum theory of Diamagnetism; Weiss Theory of paramagnetism, quantum theory of paramagnetism; Critical temperatures and saturation magnetizations of ferromagnets, Domain theory, Critical temperatures and saturation magnetizations of ferrimagnets, Critical temperatures of antiferromagnets

10hrs

Superconductivity: Critical temperatures and critical fields of the superconducting Element, Energy gaps of selected superconducting elements, Meissner effect; London equation, Structure of the BCS Theory, coherence length, supercurrent tunnelling - The Josephson effects.

10hrs

Reference Books:

1.H. P. Myers, Introduction to Solid State Physics, Viva books (1998).
2. M.A. Omar, Elementary Solid State Physics, Addison-Wesley (1975).
3. C. Kittel, Introduction to Solid State Physics, John Wiley (1996).
4. A. J. Dekker, Solid State Physics, Macmillan (1986).
5. N. W. Ashcroft and N. D. Mermin, Solid State Physics, HBC Publ., (1976).

MODEL BLUEPRINT
(Part of the syllabus)

Code number and Title of the paper: **PH 0122 - SOLID STATE PHYSICS**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Crystal physics	10	20
Lattice vibration and thermal properties	10	20
Electronic properties	10	15
Dielectrics	10	15
Magnetism	10	15
Superconductivity	10	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	To impart theoretical and experimental knowledge of structural (crystal), thermal, dielectric, magnetic, and superconducting properties of solid materials.
CO2	Understand	To understand the physical properties of solids. To understand the importance of solid-state physics in recent advances in technology.
CO2	Apply	To apply solid-state physics concepts in the subjects of material science and nanotechnology.
CO3	Analyze	To analyze physical properties for prospective applications (solid state devices)
CO4	Evaluate	To evaluate the physical characteristics of solids, and identify the material appropriate for specific applications.
CO5	Create	To design basic P-N junction (Solar cells) using SILAR Method

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**NUCLEAR AND PARTICLE PHYSICS**
Paper Code	**PH 0220**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning out come.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split ; the time duration for which the mid semester test and SE are conducted.)

PH 0220 - NUCLEAR AND PARTICLE PHYSICS

Nuclear properties: radius-electron scattering method and mirror nuclei, size, mass, spin, moments, abundance of nuclei, binding energy, excited states.
Nuclear forces: deuteron, n-n and p-p interaction, nature of nuclear force.
10hrs

Nuclear Models: liquid drop, shell and collective models.
Nuclear decay and radioactivity: radioactive decay, detection of nuclear radiation, alpha-Gamow's theory, beta-Fermi's theory of beta decay and gamma decays, radioactive dating. 12hrs

Nuclear reactions: conservation laws, energetics, isospin, reaction cross section, Coulomb scattering, nuclear scattering, scattering cross section, optical model, compound nucleus, direct reactions, resonance reactions, neutron physics, fission, fusion. 10hrs

Particle accelerators and detectors: electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filled counters, scintillation detectors,semiconductor detectors. 10hrs

Elementary particles: forces, quantum numbers, mesons and Yukawa's hypothesis, pions, CPT theorem, strange mesons and baryons, production and decay of resonances, CP violation in K decay. 9hrs

Particle physics: Symmetries and conservation laws, Feynman diagrams, Gell-MannNishijima relation, Quark model, coloured quarks and gluons, quark dynamics, standard model. 9hrs

Reference Books:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).
2. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).
3. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
4. I. S. Hughes, Elementary Particles, Cambridge (1991).
5. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper : **PH 0220 - NUCLEAR AND PARTICLE PHYSICS**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Nuclear properties+ Nuclear forces	10	20
Nuclear Models	12	20
Nuclear reactions	10	15
Particle accelerators and detectors	10	15
Elementary particles	9	15
Particle physics	9	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	To know: the methods used to calculate basic nuclear properties, different kinds of fundamental particles and their classification, different kinds of nuclear reactions and the conservation laws that govern the subatomic world
CO2	Understand	Understand the role of quantum mechanics in nuclear decays, understand momentum conservation in nuclear reactions and fundamental particles and their interactions, to understand the limitations of nuclear forces in nature.
CO2	Apply	Apply conservation laws for the nuclear and particle reactions, to draw Feynman diagrams, to apply QCD for three quark and two quark bound systems. Application of Born approximation and Fermi-golden rule to establish transition from discrete to continuum state as the application of Quantum Mechanics in nuclear physics.
CO3	Analyze	Analyze: the concepts used to build different types of particle accelerators and nuclear processes.
CO4	Evaluate	Evaluate which type of particle accelerators are best suitable for what purposes.
CO5	Create	Construct problems in particle physics with the help of Feynman diagrams.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**ELECTIVE-I (ASTROPHYSICS)**
Paper Code	**PHDE 0420**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PHDE 0420 - ELECTIVE-I (ASTROPHYSICS)

A Survey of Astronomy and Astrophysics and the Application of Scientific Process in Physics (with use of images, data analysis software like ds9 and Aladin and simulation software like Stellarium, data platforms: Mikulsky Archive, BATSE, Swift, Fermi, X-Ray, SDSS etc. and use of NASA ADS Abstract query forms and Astro-ph): Physics of Sun and solar system, Interstellar medium and the Milkyway Galaxy, Star formation regions, Stars and Types - a manifestation of Thermodynamic Equilibrium, Galaxies and Galaxy clusters, Gamma Ray Bursts using BATSE data, X-ray binaries using HEASARC data, Exoplanets, Merging Black-holes and neutron stars, Hubble's Law (using SDSS data), Other very recent discoveries and results in Astrophysics.

30 hrs

Multiwavelength Astronomy (with special lectures by experts):
Gamma-ray, X-ray, UV, Visible, Infrared, Radio and Gravitational Wave Astronomy

10 hrs

Physics of Astrophysics:

Gravitation: Kepler's Laws, The Electromagnetic Spectrum, Transmission through atmosphere and extinction, Magnitude scale, Color Indices

2 hrs

Telescope: parameters - Diffraction limit, plate scale, F/D ratio, FOV, brightness and resolution. The specifications of a good telescope.

6 hrs

Radiation: Thermal radiation, Thermal bremsstrahlung, Synchrotron radiation

5 hrs

Stars and Stellar Evolution: The equation of hydrostatic equilibrium, Virial theorem, the internal temperature of the sun, the energy generation in the centre, nuclear reactions, Eddington's theory of the stars, Mass-luminosity relation, the lifetime of the stars of different masses, the solar neutrinos, The evolution of stars, the end states of stars, white dwarfs, the Chandrasekhar limit, Neutron stars, Supernovae, Black holes. (partially covered in the first part)

2 hrs

Hands-on Activities (using SDSS):
Color-Magnitude Diagram and H-R Diagram
Supernovae
Hubble
Quasars 5 hrs

References:

1. Physical Universe, Shu F.H., University Science Books, 1982
2. An Invitation to Astrophysics, T. Padmanabhan, World Scientific, 2006
3. Structure and Evolution of Stars, Martin Schwarzschild, Princeton University Press, 1958
4. The Sun, Stix M., Springer-Verlag, 1989
5. The Physics of Fluids and Plasmas, Arnab Rai Choudhuri, Cambridge University Press, 1998
6. An Introduction to Galaxies and Cosmology, Edited by Mark H. Jones and Robert J. Lambourne, Cambridge University Press, 1998
7. Galactic Astronomy, Binney and Merrifield, Princeton Series in Astrophysics, 1998
8. Galaxies in the Universe, Sparke & Gallagher, Cambridge Univ. Press, 2000
9. High Energy Astrophysics Vol-I &II, Longair M., Cambridge Univ. Press, 1992
10. Introduction to Cosmology, Ryden B., Cambridge Univ. Press, 2002

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PHDE 0420 - ELECTIVE-I (ASTROPHYSICS)**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Survey of Astronomy	30	50
Multiwavelength Astronomy	10	15
Gravitation	2	5
Telescope	6	10
Radiation	5	10
Stars and Stellar Evolution	2	5
Hands-on Activities	5	5
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{\textit{Number of teaching hours allotted for that chapter} \times \textit{maximum marks (including marks for bonus questions}}{\textit{Total number of teaching hours (including self study hours)}}$$

Course Outcomes: At the end of the Course, the Student will be able to

CO1	Knowledge	Know the differences between the scientific process and pseudoscience; also that Astrophysics belongs to a category of *a-posterior* Science that, like Forensic Science, requires its deductions to strictly adhere to the observations (or results from experiments). Know that the study of astrophysical systems gives us knowledge of physics that helps all of humankind and advances technology for the betterment of humans.
CO2	Understand	Understand the role that classification plays in science in general with specific examples in Astrophysics
CO2	Apply	Apply basic physics to arrive at order of magnitude estimates of various physical quantities associated with astronomical systems.
CO3	Analyze	Analyze data publicly available to view deeper relationships in physical quantities related to astronomical sources.
CO4	Evaluate	Evaluate some historic and some contemporary research papers in Astronomy and through this, learn how to read papers.
CO5	Create	Create images and graphs of physical properties from publicly available data and from this analyze the physics of these systems.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**ELECTIVE II-MATERIALS SCIENCE**
Paper Code	**PHDE 0522**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

PHDE 0522- ELECTIVE II-MATERIALS SCIENCE

Semester-IV **Credits: 4**

Introduction to material sciences: Electrical: Van-der Pauw technique - measuring resistivity in thin sheets, Four probe method - measuring resistivity of semiconducting films - temperature-dependent resistivity, Hall effect method - to determine Hall coefficient - P and N-type semiconductor; thermal characterizations: TGA - Thermal stability and decomposition analysis,

Seebeck effect, Figure of merits, New thermoelectric materials

Phase diagrams of one, two and many component systems, Phase transitions - composite, Iron-Carbon Alloys, Shape memory alloys, Martensite and Austenite transformations

Quantum confinement effect, Bohr atomic radius, confined states in quantum wells, wires and dots, density of states in quantum wells, wires and dots, Superlattice structure, multilayer structure, Multiple Quantum well structures (multiple exciton generation) and applications.

20 hours

Materials important to research and modern society

1. **Energy devices:** Introduction to energy devices, High capacity batteries (Li-ion, Li polymers, Li-sulphur), storage mechanisms in each of these batteries, Solar cells - substrate and superstrate structure, (Introduction, Quantum Dot cells, thin-film cells, Perskovite cells, Organic cells)

   15 hours
2. **Spintronics devices:** Mott model, Introduction to RKKY interaction, GMR and TMR devices, Introduction to basic topology, Quantum Hall effect, Fermi surfaces, Prediction of topological insulators and what are they, synthesis by molecular beam epitaxy, applications to the modern world

   15 hours
3. **Optoelectronics:** Introduction to Phosphorescence and Fluorescence (the quantum mechanical picture), common Phosphorescent and Fluorescent Materials and their synthesis, applications to modern photonics, the theory of Light Emitting Diodes, Historic developments, modern developments and synthesis techniques (*Czochralski crystal growth method, Liquid Phase Epitaxy, Photoresist lithography etc),* White LEDs, Organic LED, Quantum-Dot LED, Light Emitting Capacitor, Introduction to Nonlinear optics (recap of semester 3 optics section), Materials with Non-Linear Optical properties

   10 hours

REFERENCES:

1. Material Science & Engineering, V.Raghavan, Prentice -Hall of India, New Delhi (2001)
2. Callister's Materials Science and Engineering by R. Balasubramaniam
3. Solid State Chemistry and its Applications by Anthony R. West
4. Non-linear optics - Robert Boyd
5. The Blue Laser Diode: The complete story - Shuji Nakamura
6. A brief introduction to giant magnetoresistance - Liu Chang
7. Handbook of Spintronics - Y Xu
8. Magnetoelectronics - Mark Johnson
9. Semiconductor Optoelectronics - Jasprit Singh

MODEL BLUEPRINT

(Part of the syllabus)

Code number and Title of the paper: **PHDE 0522- ELECTIVE II-MATERIALS SCIENCE**

Chapter	Number of teaching hours (As mentioned in the syllabus)	Maximum marks for which questions are to be framed from this chapter (including bonus questions)
Introduction to material sciences	15	25
Energy devices: Introduction to energy devices	20	35
Spintronics devices	15	25
Optoelectronics	10	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

$$\frac{Number\ of\ teaching\ hours\ \ allotted\ for\ that\ chapter\ \times maximum\ marks\ (including\ marks\ for\ bonus\ questions}{Total\ number\ of\ teaching\ hours\ (including\ self\ study\ hours)}$$

Course Outcomes: At the end of the Course, the Student

CO1	Knowledge	Impart an in-depth knowledge of materials, their properties and the phase diagrams, up-to-date knowledge of the current status of research and its applications.
CO2	Understand	Should be able to understand the material behavior and calculate/ predict their atomic, molecular and crystalline properties using appropriate equations. To understand the Quantum mechanical concepts at nanoscale. To understand the role of materials in various applications like energy devices and optoelectronics devices.
CO2	Apply	To apply the theoretical knowledge to tailor the material properties for their research needs.
CO3	Analyze	Should be able to analyze and interpret data and use scientific judgment to draw conclusions.
CO4	Evaluate	To evaluate the properties of different materials for a specific application, for example: device fabrication
CO5	Create	Should be able to design simple systems and simple components as the first step towards material science research. To prepare novel energy materials.

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**Applied Physics Lab**
Paper Code	**PH0P1**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**ELECTIVE: Material Science Lab**
Paper Code	**PH0P2**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**ELECTIVE: Astrophysics Lab**
Paper Code	**PH0P3**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**50**
Number of credits	**2**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**IV**
Title of the paper	**DISSERTATION PROJECT**
Paper Code	**PH0P4**
Number of teaching hours per week	**8**
Total number of teaching hours per semester	**100**
Number of credits	**4**

Note : (i) Kindly add the List of Reference books towards the end of the syllabus.

(ii)The syllabus may have the Statement of Learning outcome.

(iii)The introductory part of the syllabus may have vision and mission statement of the department and the examination pattern (eg: 30% for CA and 70% SE and also how the 30% marks are split; the time duration for which the mid-semester test and SE are conducted.)

Labs for Semester IV (4 Credits 8 Hours/Week)
PH0P1 - Applied physics lab
1. Calibration of a gamma-ray spectrometer using gamma-ray of known energy, finding its resolution and determining the energy of the gamma-ray from an unknown source and calculation of Compton edge.
2. Calibration of a given Lock-in amplifier and determining its amplification factor.
3. To determine the mutual inductance of a given coil using a calibrated lock-in amplifier.
4. Determining the linear attenuation coefficient of paper, Cu and Pb using the GM counter.
5. To determine the resistance of an extremely low-value resistor using a calibrated lock-in amplifier
6. Studying the counting statistics for a GM counter
7. To determine the Hall coefficient of a given magnetic sample and determine its temperature dependence.
8. Measurement of dead time of a GM counter - Two source method
9. Introduction to DFT using Quantum Espresso (16Hrs)
a)Total energy and scf calculations b)Electronic properties c)Lattice Oscillations d)Optical properties e)2D materials
10. Any other applied or computational physics experiments which the department deems to be included.

Elective Labs for Semester IV (4 Credits 8 Hours/Week)	
PH0P2- Astrophysics	**PH0P3-Material Science**
1. Astrophysical Resources and Tools	Curie-Weiss Law
2. CCDs and Photometry: 10x10 image reduction program development	Seebeck Coefficient
3. Beginning IRAF (Using IRAF for the 10x10 image, Using a 1000x1000 image); *imarith* and *imstat*	Resistivity measurement techniques -Vander-paw method
4. Basic Photometric Reduction with IRAF - Part I; *imhead*, *imexamine*, *qphot*	Direct measurement of Piezoelectric constant of PVDF film.
5. Observatory Trip	Synthesis and characterization of MO/MS Nanoparticles by Chemical precipitation/Microwave method
6. Basic Photometric Reduction with IRAF - Part 2; *imhead*, *imexamine*, *qphot*	Thermal Diffusivity
7. Basic Spectroscopic Reduction with IRAF - Part; *fit1d*, *apall*	B-H Curve for hard ferromagnetic material and a soft ferrite
8. Basic Spectroscopic Reduction with IRAF - Part 2; *unlearn*, *splot*	Synthesis and Characterization of ZnO Thin films Grown by SILAR method
9. Basic Spectroscopic Reduction with IRAF - Part 3; *identify*, *refspec*, *dispcor*	Thermal and Electrical conductivity of Copper
	Four Probe Method

Labs for Semester IV (4 Credits 8 Hours/Week)
PH0P4 - Dissertation Project
Students’ Choice of supervisors; weekly internal progress review (2-3 hrs)