ST. JOSEPH'S COLLEGE

(AUTONOMOUS)

BENGALURU-27

Re-accredited with **'A++' GRADE with 3.79/4 CGPA** by
NAAC Recognized by UGC as College of Excellence

DEPARTMENT OF PHYSICS

SYLLABUS FOR POSTGRADUATE PROGRAMME

For Batch 2021-2023

Part B

M.Sc. Physics Curriculum

Courses and course completion requirements	No. of credits
Physics	94
Open elective courses (non-professional)	2
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 7121:** 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 7520:** Analytical Tools in Mathematical Physics - I	44	02	50
		TOTAL	**24**	**600**
SEMESTER II				
THEORY				
Paper I	**PH 8121:** Electrodynamics	60	04	100
Paper II	**PH 8221:** Experimental Physics - II	60	04	100
Paper III	**PH 8321:** 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 8520:** 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 9421:** Quantum Mechanics - I	60	04	100
Paper V	**PH 9521:** Physics SoftCore	30	02	50
Paper V (OE)	**PHOE 9518:** Astrophysics Open Elective	30	02	35
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	**28**	**700**
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 0421:** Astrophysics	60	04	100

Paper III-B (**DE**)	**PHDE 0421:** Materials Science	60		
PRACTICAL				
Paper I	**PH 0P1:** Nuclear and Experimental Physics Lab	44	02	50
Paper II-A (DE)	**PH 0P2:** Material Science Lab	44	02	50
Paper II-B (DE)	**PH 0P3:** Astrophysics Lab			
Paper III	**PH 0P4:** Dissertation Project	88	04	100
		TOTAL	**20**	**500**
Total No. of Credits : 96				
KEY WORDS: DE – Departmental Elective and OE – Open Elective				

CORE COURSES (CC)	
Course Title	Code Number
Classical Mechanics	**PH 7121**
Mathematical Physics	
Quantum Mechanics - I	
Quantum Mechanics - II	
Statistical Physics	
Electrodynamics	

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number
Materials Science	**PHDE 0521**
Astrophysics	**PHDE 0421**

GENERIC ELECTIVE COURSES (GSE)/ Can include open electives offered	
Course Title	Code Number
Astrophysics Open Elective	**PHOE 9518**

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 7521**
Analytical Tools in Mathematical Physics - II	**PH 8521**

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	**1**
Title of the paper	**CLASSICAL MECHANICS**
Paper Code	**PH 7121**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60**
Number of credits	**4**

PH 7121 - CLASSICAL MECHANICS

Lagrangian formulation :
Mechanics of a particle, Mechanics of a system of particles, Constraints, Generalized coordinates, D'Alembert's principle, Lagrange's equations of motion, Simple applications of the Lagrangian formulation, Galilean invariance of Lagrange's equations 11hrs

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 15hrs

Hamiltonian formulation :
Legendre transformations, Hamilton's equations of motion – 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 10hrs

Continuum Mechanics:
Strings, D'Alembert's solution to the wave equation – Energy density and energy current; Reflection at an interface; Mass point on a string; Interface between strings of different mass density, Finite strings – Bernoulli's solution, Sturm-Liouville Theory – Variational method, Continua in Higher dimensions – Membranes; Helmholtz equation; Rectangles; Circles; Sound in fluids, Dispersion
10hrs

Rotational motion:
Rotating frame of reference, inertial forces in rotating frames, Coriolis force, Foucault pendulum, Deviation due east of a falling body 6hrs

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 7121 - CLASSICAL 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)
Lagrangian formulation	11	20
Variational principle	8	15
Central force	15	25
Hamiltonian formulation	10	15
Continuum Mechanics	10	15
Rotational motion	6	10
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

[illegible] × [illegible] ([illegible]

[illegible] ([illegible])

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 1^{st} 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)

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(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:

[illegible] [illegible] × [illegible] ([illegible]

[illegible] ([illegible])

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.

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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

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(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:

[illegible] × [illegible] ([illegible]

[illegible] ([illegible])

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.

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(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:

[illegible] ×[illegible] ([illegible])

[illegible] ([illegible])

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:

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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	
Op-amp inverting-non inverting and Summing amplifier	Power Method for Eigenvalues
Integrator and Differentiator	Gauss Elimination
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
Triangular Wave generator	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
Signal conditioning with an instrumentation amplifier	Normal Distributions
Second-order Band Pass and Band Reject filters	Poisson Distributions
	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	**PH7519**
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 (2 Credits, 4 Hours/Week)	
1. Introduction to Core Python Programming and Numpy	10hrs
2. Introduction to Computer Algebra System (CAS) Maxima	8 hrs
3. 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

The syllabus title must be as given below:

DEPARTMENT OF PHYSICS

Semester	**2**
Title of the paper	**ELECTRODYNAMICS**
Paper Code	**PH 8121**
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 8121 - ELECTRODYNAMICS

Multipole expansions and material media: Multipole expansions for a localised charge distribution in free space, Magnetostatics-Divergence and curl of a magnetic field, magnetic vector potential, it's multipole expansion, static electric and magnetic fields in material media, Boundary condition

10 hrs

Time-varying fields: Time dependents field, Faraday's law for stationary and moving media, Maxwell's displacement current, Differential and Integral forms of Maxwell's equations, Maxwell's equations for material medium. 6hrs

Energy, Force and Momentum relations in electromagnetic fields: Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Conservation laws. 6hrs

Electromagnetic wave equations: Electromagnetic wave equations, Electromagnetic plane waves in a stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth. 8hrs

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

Relativistic Kinematics: Experimental basis for the special theory of relativity (Michelson - Morley experiment), 2 Lorentz transformations, Relativistic velocity addition, Mass- Energy relation (E=mc2).

4hrs

Covariance and Relativistic Mechanics: Minkowski's space-time diagram, light cone, Four vectors, Lorentz transformation of Four vectors, Some tensor relations useful in special relativity, Minkowski's force. 6hrs

Covariant formulation of electrodynamics: Magnetism as a relativistic phenomenon, Electromagnetic field tensor, Lorentz force on a charged particle. 5hrs

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. Special Theory of Relativity, by Robert Resnick.
9. Electromagnetics by B.B.Laud, Willey Eastern.
10. Matrices and Tensors in Physics, A. W. Joshi, 3 Edition, New Age International
11. Modern Electrodynamics, Andrew Zangwill, Cambridge University Press (2013)
12. Electricity and Magnetism, Purcell, E.M., Morin, D.J., Cambridge University Press (2013)

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(Part of the syllabus)

Code number and Title of the paper: **PH 8121 - ELECTRODYNAMICS**

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 and material media	10	15
Time-varying fields	6	10
Energy, Force and Momentum relations in electromagnetic fields	6	10
Electromagnetic wave equations	8	15
Inhomogeneous wave equations	15	25
Relativistic Kinematics	4	5
Covariance and Relativistic Mechanics	6	10
Covariant formulation of electrodynamics	5	10
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

[illegible]

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.

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(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:

[illegible] ×[illegible] ([illegible]

[illegible] ([illegible])

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**
Paper Code	**PH 8321**
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 8321 - STATISTICAL PHYSICS

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.
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. 6hrs

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.
8hrs

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. 12hrs

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. 11hrs

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.
9hrs

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.
9hrs

Reference Books :

1. Fundamentals of Statistical and Thermal Physics, - F.Reif, McGraw - Hill, International Edition (1985)
2. Fundamentals of Statistical Mechanics, B.B.Laud, New Age International Publication (2003)
3. Statistical Mechanics, R.K.Pathria, Bufferworgh Heinemann(2 Edition)
4. An Introduction to Statistical Mechanics and Thermodynamics, Robert H. Swensden, Oxford University Press (2012)
5. Statistical Physics of Particles, Mehran Kardar, Cambridge University Press (2007)
6. Statistical Mechanics, K.Huang, John Willey & Sons (2 Edition)
7. Statistical Mechanics by Lokanathan and Gambhir.

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(Part of the syllabus)

Code number and Title of the paper: **PH 8321 - STATISTICAL 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)
Statistical Description of System of Particles	5	10
Thermodynamics	6	10
Classical Statistical Mechanics	8	10
Applications of Statistical Mechanics	12	20
Quantum Statistics of Ideal Gases	11	20
Ideal Bose System	9	15
Ideal Fermi System	9	15
Total marks excluding bonus questions		70
Total marks including bonus questions		100

Formula to calculate the maximum marks for each chapter:

[illegible] × [illegible] ([illegible])

[illegible] ([illegible])

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)

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(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:

[illegible] ×[illegible] ([illegible]

[illegible] ([illegible])

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 wavefunction, 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:

[illegible] ×[illegible] ([illegible]

[illegible] ([illegible])

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**
Comparison of capacitances	RS flip flop and decade counter
Stefan's constant	Astable and monostable multivibrator
Thermal relaxation	DAC: Weighted resistors and R-2R network
Cu-Constantan Thermocouple and Si diode	Amplitude Modulation and demodulation
Thermal and electrical conductivity of copper	Frequency Modulation and demodulation
High resistance by leakage	Pulse amplitude modulation and demodulation
Passive filters	ADC – IC 0804
AC bridges	Multiplexer and demultiplexer
Absorption spectrum of copper sulphate	Voltage-controlled oscillator: IC 555 and phase Lock Loop IC 565
Thermal diffusivity	Frequency multiplication
	DAC – IC 1408
	Design a circuit with a real-world application using the concepts learnt in this lab.

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	**PH8519**
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 (2 Credits, 4 Hours/Week)
1. Complex variables using Maxima and Python a. Meaning of analyticity and Plotting a complex function in maxima b. Contour plots of functions in maxima and python c. Convergence of series using maxima d. Residues of complex functions using maxima 16hrs
2. Integrals in Maxima 8hrs
3. Fourier Analysis: a. Fourier series in maxima b. Convolution example(s) in maxima 10hrs
4. Special functions in maxima a. Comparing Bessel function series to built-in Bessel functions b. Built-in functions: Hermite, Legendre, Laguerre 16hrs