B.Sc. THIRD YEAR

Mathematical Physics and Classical Mechanics

Tribhuvan University
Institute of Science and Technology
Physics Subject Committee
Central Department of Physics

Course Title: (**Mathematical Physics and Classical Mechanics**) **Year:** III
Full Marks: 100 **Pass Marks:** 35
Course No.: PHY301 **Nature of Course:** Theory

Course Objectives:

At the end of this course the student should be able to acquire sufficient knowledge in mathematical physics and classical mechanics and apply this knowledge for higher studies and research in physics.

MATHEMATICAL PHYSICS (60%) [96 hours]

1. **Vector analysis: 1.1** Scalar and vector fields, 1.2 law of transformation of vectors, polar and axial vectors, solenoidal vectors, rotational and irrotational vectors, vortex lines, 1.3 Curvilinear coordinates: direction cosines, scale factors, curvature of co-ordinate lines, volume element, rotation of axes, contravarient and covariant vectors, 1.4 Gradient, divergence, curl and Laplacian in curvilinear co-ordinates, 1.5 Special orthogonal curvilinear coordinates: cylindrical, spherical, ellipsoidal, hyperbolic and parabolic co-ordinates [20 hours]
2. **Tensor analysis: 2.1** Contravariant, covariant and mixed tensors, 2.2 Kronecker delta, tensors of rank greater than two, scalars or invariants, 2.3 Tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, stress tensor, 2.4 Line element and matric tensor, reciprocal tensors, associated tensors, length of a vector, angle between vectors, physical components, 2.5 Christoffel's symbols, transformation laws of Christoffel's symbols, geodesics, covariant derivatives, 2.6 Tensor form of gradient, divergence, curl and Laplacian [20 hours]
3. **Linear vector spaces: 3.1** Vectors in n-dimensions, linear independence, inner product, 3.2 Schwartz inequality, 3.3 Representation of vectors and linear operators with respect to a basis, change of basis, 3.4 Schmidt orthogonalization process, 3.5 Linear operators and their matrix representation: symmetric, Hermitian, orthogonal, unitary (normal) matrices, 3.5 Determination of eigen values and eigen vectors of the matrix, diagonalization [18 hours]

4. **Fourier series and transforms: 4.1** Fourier series representation, even and odd functions, 4.2 Fourier series expansion of square, triangular, saw-tooth waves and out put of full wave rectifier, 4.3 Complex representation of Fourier series, 4.4 Dirac delta function, 4.5 Parseval relation, 4.6 Fourier transform and convolution theorem, 4.7 Laplace transform, Laplace transform of derivatives and integrals, 4.8 Use of Fourier and Laplace transform in solving partial differential equations. [18 hours]
5. **Differential equations: 5.1** Series solutions of Bassels's, Legendre's, Hermite's, Laguerre's differential equations, 5.2 Rodrigue's formula, Recurrence relations, associated Legendre and Laguerre polynomials, orthogonality and generating functions [10 hours]
6. **Partial differential equations: 6.1** Wave equations, Laplace, Poisson and diffusion equations, boundary value problems, 6.2 Method of separation of variables [10 hours]

CLASSICAL MECHANICS (40%) [64 hours]

7. **Motion in Central Field**: 7.1 Motion in central force field, motion in arbitrary potential field, equation of orbits, 7.2 Kepler's laws of planetary motion [6 hours]
8. **Elastic and Inelastic Collision**: 8.1 Collision of particles, collision in laboratory and center of mass systems, cross section, 8.2 Rutherford scattering [6 hours]
9. **Elementary Principles: 9.1** Constraints, 9.2 Generalized coordinates, generalized displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force and generalized potential, 9.3 D'Alembert's principle and Lagrange's equations [10 hours]
10. **Variational Principles and Lagrange's Equations: 10.1** Calculus of variations: Geodesics, Minimum surface of revolution, The brachistochrone problem, 10.2 Hamilton's principle and derivation of Lagrange's equation, Extension of Hamilton's principle to nonholonomic systems (Method of Lagrange undetermined multipliers), 10.3 Conservation theorems and symmetry properties, 10.4 Energy function and the conservation of energy [12 hours]
11. **Inertial Frames**: 11.1 Moving co-ordinate system, translating and rotating co-ordinate systems, 11.2 Coriolis force, Foucault pendulum [6 hours]
12. **Motion of Rigid Bodies**: 12.1 Motion of rigid body, 12.2 Euler's theorem, angular momentum and kinetic energy, the inertia tensor, 12.3 Euler's equation of motion, torque free motion, Eulerian angle, symmetrical top [10 hours]
13. **Relativity: 13.1** Gallilean invariance, inertial frames of reference, 13.2 Gallilean transformations, non-inertial frames and fictitious forces, 13.3 Michelson-Morley experiment, 13.4 Lorentz transformation, length contraction, time dilation, transformation and addition of velocities, variation of mass with velocity, 13.5 Mass energy relation, 13.6 relation between momentum and energy, 13.7 transformation of energy and momentum. [10 hours]

Text Books:

1. *Mathew, J. & Walker, R*. - **Mathematical Methods in Physics**, Benjamin Menlo Park, Second Edition (1970)

2. *Spiegel, Murray R.* - **Vector Analysis (Schaum Series)**, McGraw Hill, London (1992)

3. *Harper C.* - **Introduction to Mathematical Physics**, Prentice Hall of India Pvt. Ltd. (1990)

4. *Goldstein Herbert, Poole Charles and Safko John* - **Classical Mechanics;** Addison-Wisley (2002)

5. *Mathur D. S.* - **Mechanics**; S. Chand & Company Ltd., New Delhi, (2008)

6. *Murugeshan R. and Sivaprasad K.* - **Modern Physics**, S. Chand & Co. Ltd. New Delhi, (2007)

References:

1. *Gupta B. D*.- **Mathematical Physics***,* Vikas Pub. House Pvt. Ltd., India (1994)

2. *Rajput B. S.*- **Elementary Mathematical Physics***,* Pragati Prakashan, India (1997)

3. *Arfken G.*- **Mathematical Methods for Physicists***,* Academic Press, New York (1970)

4. *Margenau H. and Murphy G. M.* - **The Mathematics of Physics and Chemistry***,* Krieger, New York, (1976)

5. *Pipes L. A.* - **Applied Mathematics for Engineers and Physicists**, McGraw-Hill (1970)

6. *Hinchey F. A***.**- **Vectors and Tensors for Engineers and Scientists***,* Wiley Eastern (1976)

7. *Joshi W.* - **Matrices and Tensors in Physics***,* Wiley Eastern (1995)

8. *Takwale R. G. and Puranik P. S.* - **Introduction to Classical Mechanics**, Tata McGraw-Hill (1979)

9. *Kibble T. W. B. and Berkshire F. H.* - **Classical Mechanics**, Prentice Hall (1996)

10. *Waghmare Y. R.* - **Classical Mechanics**; Prentice Hall of India Pvt. Ltd, New Delhi, (1990)

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Course Title: Physics Laboratory	**Year: III**
Course Code: PHY302	**Full Marks:** 50
Nature of Course: Practical	**Pass Marks:** 20

Course Description:

Physics Laboratory (General) Practical course consists of three sections: (a) Modern Physics Experiments, (b) Optical Experiments, (c) Nuclear Experiments, and (d) Electronic Experiments. Students have to perform at least 15 experiments in 180 working hours. Students are required to perform 3 hours laboratory work twice in a week. Students should complete at least 20 experiments in the third year. Students need to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed.

Course Objectives:

1. To provide students with skill and knowledge in the experimental methods.
2. To make them able to apply knowledge to practical applications.
3. To make them capable of presenting their results/conclusions in a logical order.

PHYSICS THIRD YEAR LAB WORKS [180 hours]

1. Calibrate the experimental set-up of photoelectric effect using yellow filter, standard value of planck's constant and work function of the given photocell. Find calibration factor.
2. Study photoelectric effect and estimate the value of Planck's constant using various color filters.
3. Study photoelectric effect and find the wavelength of the unknown color filters using calculated value of planck's constant *h*.

4. Use the measured dataset of photoelectric effect and calculate the standard deviation, standard error and probable error with significant figures. Generate theoretical data using photoelectric equation for given filters and photocell. Test how well the measured data agrees with the theoretical data in this experiment. Show the trend of measured and theoretical data in a graph and interpret it.
5. Study the activity of given γ-radioactive source using GM counter. Show that the gamma rays obey inverse square law.
6. Study the absorption of gamma rays by the given absorber and GM counter. Find the value of linear absorption coefficient.
7. Use measured dataset of the experiments 6, calculate the standard deviation for each absorber material, and then standard error and probable error with significant figures. Generate theoretical data using radioactive equation and study the differences in the measured and theoretical data.
8. Use the method of least square, draw the best straight line through a set of measured data in the experiment 6 with error bar and find the error in slope and intercept.
9. To study the level of natural background radiation at the laboratory in the given condition.
10. To study the level of natural background radiation in the outdoor field in all directions (east, west, north, south, up and down) in the given condition.
11. Use the dataset of experiment 10 and find the standard error in all directions separately. Compile this database in a single set and make a histogram showing Gaussian like distribution. Interpret the result.
12. To study the Michelson Interferometer to determine the wavelength of monochromatic light.
13. To use the microwave source for studying the phenomenon of (a) Refraction, (b) Interference, (c) Diffraction, and (d) Polarization.
14. To study the band gap of semiconductor using leakage current method.
15. Study the working of fine beam tube for the determination of the specific charge of an electron.

16. Study the functioning of Earth inductor and determine the dip using it.
17. Study the working of CRT for the determination of specific charge of electron.
18. To estimate the current gain (β) in a Common-Emitter Configuration.
19. Construct CE amplifier and determine the voltage gain of the amplifier with phase relation.
20. Construct CC amplifier and determine the voltage gain, input and output impedance with phase relation.
21. Construct CS amplifier and determine the voltage gain of the amplifier with phase relation.
22. Study the characteristic of inverting and non-inverting operational amplifier (Using IC).
23. To study operational amplifier for integrator (Using IC).
24. To study operational amplifier for differentiator (Using IC).
25. To study the working of half-adder and half-subtractor circuit.
26. Design and constructs the 1-bit digital comparator.
27. To study the astable multivibrator by using transistors and find its frequency and duty cycle.
28. To study the characteristics of phase shift oscillator.
29. To study the drain and transfer characteristics of junction field effect transistor (JFET).
30. To study the characteristics of uni-junction transistor.

Text Books

1. *Arora C. L.* - **B.Sc. Practical Physics**, S. Chand and Company Ltd. (2010)

2. *Squires G. L.* - **Practical Physics,** Cambridge University Press (1999)

Evaluation Scheme

1. Student must perform three periods laboratory work twice a week to complete both PHY302 lab works.
2. PHY302 will be examined for the duration of six hours in two different three hours sessions.
3. The practical exam will be graded on the basis of the following marking scheme:

Record file:	20%
Experiment:	50%
Error Analysis:	10%
Viva:	20%

ELECTIVE PAPERS

Applied Mathematics

Tribhuvan University
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Physics Subject Committee
Central Department of Physics

Course Title: Applied Mathematics	**Year:** III
Full Marks: 50	**Pass Marks:** 17.5
Nature of Course: Theory(Elective)	**Course No.:** PHY304

Course Objectives:

At the end of this course the student should be able to acquire sufficient knowledge of applications of mathematical tools in physics and apply this knowledge for higher studies and research in physics

APPLIED MATHEMATICS [80 hours]

1. **Applications of differential equation:** 1.1 Differential equation of particle dynamics 1.2 Differential equation of electric circuit theory 1.3 Differential equation in nuclear physics 1.4 Differential equation in geometry 1.5 Elimination of arbitrary constant from a functional relation 1.6 Determination of arbitrary constants – initial and boundary value problems 1.7 Problems leading to first order equation with the variable separable 1.8 Problem leading to first order linear equations 1.9 Dynamical problem leading to ordinary linear differential equations 1.10 The damped harmonic oscillators: free vibrations 1.11 Systems of several masses 1.12 Geared systems [20 hours]
2. **Electric circuit theory:** 2.1 Electrical networks 2.2 Mechanical analogies 2.3 Steady state theory: Impedance 2.4 Filter circuits – variation of impedance with frequencies 2.5 Oscillator circuit: stability 2.6 Impulsive motion [10 hours]
3. **Particle dynamics:** 3.1 Function of position 3.2 Function of velocity 3.3 Non-linear problem in electric circuit theory 3.4 Oscillation of non-linear systems 3.5 Relaxation oscillation 3.6 Motion in two or more dimensions 3.7 Motion on a fixed plane curve 3.8 Central Forces 3.9 Motion of a particles whose mass varies [15 hours]

4. **Rigid dynamics:** 4.1 moments and products of inertia 4.2 Fundamental equations 4.3 Motion about a fixed axis 4.4 Motion in two-dimension 4.5 Problems of rolling and sliding 4.6 Impulsive motion 4.7 The gyrostat [15 hours]
5. **Applications of Fourier series:** 5.1 Fourier series in electric circuit theory 5.2 Fourier series in mechanical problems 5.3 Fourier series in boundary value problems 5.4 Double and multiple Fourier series 5.5 Fourier transforms: applications [10 hours]
6. **Applications of partial differential equations:** 6.1 The wave equation in one-dimension: simple solutions 6.2 The equations for the uniform transmission line 6.3 The Laplace equation in two dimensions 6.4 The use of Fourier series 6.5 The use of Laplace transformation 6.6 The use of conformal representation 6.7 Equation of continuity [10 hours]

Text Book:

1. *Jaeger J. C.* - **Introduction to Applied Mathematics**, Second Edition, Oxford University Press (1974)

Reference Books:

1. *Nearing J.* - **Mathematical tools for physics**, First Edition, University of Miami (2003)

2. *Mulholland H. & Phillips J. H. G***. - Applied Mathematics for Advanced level**, Butterworth & Co. Ltd (1969)

3. *Potter M. C. & Goldberg J*. - **Mathematical Methods**, Second Edition, Prentice Hall of India Pvt Ltd. (2000)

ELECTIVE PAPERS

Space Science

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Course Title: Space Science	**Year:** III
Full Marks: 50	**Pass Marks:** 17.5
Nature of Course: Theory / Elective	**Course No.:** PHY305

Course Objectives

At the end of this course the student should be able to acquire fundamental knowledge of space related science and technology and to apply it in the higher studies and research in physics

SPACE SCIENCE [80 hours]

1. **Space Systems:** 1.1 Basic of orbital Mechanics 1.2 Concepts of orbits – propulsion 1.3 Aerodynamics, navigation, guidance and control systems 1.4 History and developments of Manned and Unmanned Space travel 1.5 Rocket launch technology [10 hours]
2. **Physics of Remote Sensing:** 2.1 Introduction – Electromagnetic Spectrum 2.2 Effects of Atmosphere – Fundamentals of Radiometry 2.3 Spectral Reflectance 2.4 Physical basis of signatures 2.5 Data Acquisition: Remote sensors 2.6 Optical-infrared sensors 2.7 Microwave 2.8 Geographical Information System: Components of GIS – Map Projections – Spatial and Non-Spatial data – Data model and input – data analysis and output 2.9 Remote Sensing Applications: Agriculture – forestry – land use / land cover mapping – water resources – snow and glacier – wetland management [15 hours]
3. **Earth System:** 3.1 Components of Earth System -- Atmosphere – Hydrosphere – Cryosphere – Lithosphere – Biosphere 3.2 Earth crust and Mantle. 3.3 Climate System – Feedback processes in Climate System – concept of feedback 3.4 Applications of feedback to the climate system. 3.5 Equations for the Atmosphere and Oceans 3.6 Equation of Continuity 3.7 Equations of Motion 3.8 Thermodynamic Energy Equation 3.8 Equation of state 3.9 Hydrological Cycle in the Earth System; 3.10 Carbon Cycle in the Earth System; 3.11 Oxygen in the Earth System [20 hours]
4. **Astronomy:** 4.1 Solar system 4.2 Comets and Asteroids 4.3 Exoplanets 4.4 Types and Population of stars 4.5 Magnitudes – apparent and absolute 4.6 Distance-magnitude relation 4.6 Extinction, 4.7 Hydrodynamic equilibrium 4.8 Linear Stellar

Model 4.9 Gaseous Nebulae 4.10 Dust clouds & Molecular Clouds 4.11 HR diagram 4.12 Stellar nucleosynthesis 4.12 Stellar spectra 4.13 Telescopes and Detectors at various wavelengths. [20 hours]

5. **Space Dynamics:** 5.1 Virial theorem and gravitational collapse 5.2 Thermodynamics: Heating and Cooling of gas 5.3 Ionization and Thermal equilibrium, 5.4 HII regions 5.5 Mechanical and Radiative Equilibrium 5.6 Evolution of the Universe: Hubble's law 5.7 Primordial nucleosynthesis 5.8 Cosmic background radiation 5.9 Galaxy rotation curve 5.10 Need for Dark Energy. [15 hours]

Text Books:

1. *Hale, F. J*.- **Introduction to Space Flight**, Prentice Hall (1994).

2. *Joseph G.* - **Fundamentals of Remote Sensing,** Second Edition, Universities Press (2005)

3. *Wallace J. M. and Hobbs P. V.* - **Atmospheric Science**, An Introductory Survey, International Geophysical Series (2006)

4. *Carroll B W & Ostlie D A* - **An Introduction to Modern Astrophysics**, Latest Edition, Addison-Wesley.

Reference Books:

1. *Wertz, J. R. and Larson, W. J.* (eds.) - **Space Mission Analysis and Design**, Microcosm Press (2006).

2. *Campbell J.B .*- **Introduction to Remote Sensing**, Fourth Edition, The Guilford Press (2008)

3. *Sparke and Gallaghar* - **Galaxies in the Universe: An Introduction**, Latest Edition, Cambridge University Press (2007)