Syllabus for
Bachelor of Science in Physics (Honours)
Under Choice Based Credit System
Academic Session:
w.e.f. 2020-2023

for

All Constituent/Affiliated Colleges Under

Binod Bihari Mahto Koyalanchal University, Dhanbad

Members of Board of Studies of CBCS Under- Graduate Syllabus as per Guidelines of the Binod Bihari Mahto Koyalanchal University, Dhanbad

1. Dr. K. Bandyopadhyay, Associate Professor – Chairman
   University Dept. of Physics, BBMKU, Dhanbad
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Two experts for UG

4. Dr. Umamageswari, Associate Professor, – Member
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COURSE STRUCTURE

Semester	Course Code	Course Name	Full Marks	End Semester Marks	Mid Semester (Internal) Marks
I	**PHY-H-C-101-T** (04 Credits, 60 Lectures)	Mathematical Physics-I	75	60	15
	PHY-H-C-102-T (04 Credits, 60 Lectures)	Mechanics	75	60	15
	PHY-H-C-101-P &102-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10
	XYZ-H-GE-101-T (06 Credits, 60 Lectures& 15 Tutorials) **or** **XYZ-H-GE-101-T** (04 Credits, 60 Lectures) **XYZ-H-GE-101-P** (02 Credits, 30 Lectures)	Choice to choose from other disciplines (Annexure-2)	100 **or** 75 25	80 **or** 60 20	20 **or** 15 5
	PHY-H-AECC-101-T Language (English/Hindi/NH+MB) (02 Credits, 30 Lectures)	Language (English/Hindi/NH+MB)	50	40	10
II	**PHY-H-C-203-T** (04 Credits, 60 Lectures)	Electricity and Magnetism	75	60	15
	PHY-H-C-204-T (04 Credits, 60 Lectures)	Waves and Optics	75	60	15
	PHY-H-C-203-P &204-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10
	XYZ-H-GE-202-T (06 Credits, 60 Lectures & 15 Tutorials) **or** **XYZ-H-GE-202-T** (04 Credits, 60 Lectures) **XYZ-H-GE-202-P** (02 Credits, 30 Lectures)	Choice to choose from other disciplines s (Annexure-2)	100 **or** 75 25	80 **or** 60 20	20 **or** 15 5
	PHY-H-AECC-202-T Environmental Science (02 Credits, 30 Lectures)	Environmental Science	50	40	10

III	**PHY-H-C-305-T** (04 Credits, 60 Lectures)	Mathematical Physics -II	75	60	15
	PHY-H-C-306-T (04 Credits, 60 Lectures)	Thermal Physics	75	60	15
	PHY-H-C-307-T (04 Credits, 60 Lectures)	Analog systems and applications	75	60	15
	PHY-H-C-305-P&306P &307-P (02+02+02=06 Credits, 60x3 Lectures)	Practical	75	60	15
	XYZ-H-GE -303-T (06 Credits, 90 Lectures) **or** **XYZ-H-GE -303-T** (04 Credits, 60 Lectures) **XYZ-H-GE -303-P** (02 Credits, 30 Lectures)	Choice to choose from other disciplines (Annexure-2)	100 **or** 75 25	80 **or** 60 20	20 **or** 15 5
	PHY-H-SEC-301-T (02 Credits, 30 Lectures)	(Annexure-1)	50	40	10
IV	**PHY-H-C-408-T** (04 Credits, 60 Lectures)	Mathematical Physics-III	75	60	15
	PHY-H-C-409-T (04 Credits, 60 Lectures)	Elements of Modern Physics	75	60	15
	PHY-H-C-410-T (04 Credits, 60 Lectures)	Digital systems and applications	75	60	15
	PHY-H-C-408-P &409-P &410-P (02+02+02=06 Credits, 60x3 Lectures)	Practical	75	60	15
	XYZ-H-GE-404-T (06 Credits, 60 Lectures& 15 Tutorials) **or** **XYZ-H-GE-404-T** (04 Credits, 60 Lectures) **XYZ-H-GE-404-P** (02 Credits, 30 Lectures)	Choice to choose from other disciplines (Annexure-2)	100 **or** 75 25	80 **or** 60 20	20 **or** 15 5
	PHY-H-SEC-402-T (02 Credits, 30 Lectures)	(Annexure-1)	50	40	10

V	**PHY-H-C-511-T** (04 Credits, 60 Lectures)	Quantum Mechanics & Applications	75	60	15
	PHY-H-C-512-T (04 Credits, 60 Lectures)	Solid State Physics	75	60	15
	PHY-H-C-511-P & 512-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10
	PHY- H-DSE-501A-T/ **PHY-H-DSE-501B-T/** **PHY-H-DSE-501C-T** (04 Credits, 60 Lectures) (Choice to choose any one paper)	Physics of Devices & Instruments/ Experimental Techniques/ Astronomy and Astrophysics	75	60	15
	PHY-H-DSE502A-T/ **PHY-H-DSE-502B-T/** **PHY-H-DSE-502C-T** (04 Credits, 60 Lectures) (Choice to choose any one paper)	Advanced Mathematical Physics/ Atmospheric Physics/ Biological Physics	75	60	15
	Phy-H-DSE-501A/B/C P & 502A/B/C-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10
VI	**PHY-H-C-613-T** (04 Credits, 60 Lectures)	Electromagnetic Theory	75	60	15
	PHY-H-C-614-T (04 Credits, 60 Lectures)	Statistical Mechanics	75	60	15
	PHY-H-C-613-P& 614-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10

	PHY-H-DSE-603A-T/ **PHY-H-DSE-603B-T/** **PHY-H-DSE-603C-T** (04 Credits, 60 Lectures) (Choice to choose any one paper)	Classical Dynamics/ Communication System/ Applied Dynamics	75	60	15
	PHY-H-DSE-604A-T/ **PHY-H-DSE-604B-T/** **PHY-H-DSE-604C-T** (04 Credits, 60 Lectures) (Choice to choose any one paper)	Nuclear & Particle Physics/ Digital Signal processing/ Nano Materials and Applications	75	60	15
	PHY-H-DSE-603A/B/C-P & 604A/B/C-P (02+02=04 Credits, 60x2 Lectures)	Practical	50	40	10
Total Marks			**2400**	**1920**	**480**

Note:

Symbol of Paper: **PHY-H-C-101-T**: The first three symbols in Roman capital letters indicate the subject; the next symbol H or G indicate Honours or General course; the next symbol(s) denotes Core (C), Generic Elective (GE), Discipline Specific Elective (DSE), AECC, SEC, etc. Out of the next three digits, the first digit indicates the semester e.g. 1,2,3,4,5,6 for semester I, II, III, IV, V, VI respectively, and the next two digits indicate paper number. The last letter T or P indicates Theory or Practical.

Annexure - 1

SKILL DEVELOPMENT COURSES (Common for All Programmes)

For Honours Degree

(i) Third Semester: Compulsory for All Disciplines

Any one of the following three in a particular college depending upon the facility available:

1. Constitution of India and Human Rights
2. Environment and Public Health
3. Computer Applications and Information Technology

(II) Fourth Semester: One from the following may be chosen

The courses may include the following:

1 Entrepreneurship
2 Life Skills and Personality Development
3 Human Resource Development
4 Legal Aid and Awareness
5 Indian History, Culture and Diversity
6 Science and Life
7 Banking and Finance
8 Building Mathematical Ability
9 Capital and Stock Market
10 Any other subject to be decided by the Academic Council.

Annexure-2

GENERIC ELECTIVES FOR PHYSICS HONOURS STUDENTS

Any one from the following may be chosen:

1. Mathematics
2. Chemistry
3. Geology
4. Statistics

SEMESTER-I

PHY-H-C-101-T: MATHEMATICAL PHYSICS-I (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Calculus: **Recapitulation**: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor. **(6 Lectures)**

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(12 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(6 Lectures)**

Vector Calculus: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.**(4 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and Curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, Divergence, curl and Laplacian in spherical and cylindrical coordinates. **(12 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Stokes theorem Green's Theorem (in a plane) and their applications. **(14 Lectures)**

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
3. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book.
4. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
5. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
6. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press
7. Mathematical Physics, H K Das and Dr. Rama Verma, S. Chand and Company Limited.
8. Mathematical Physics, B D Gupta, Vikash Publishing House, 4^{th} edition.
9. Mathematical Physics, B S Rajput, Pragati Prakashan.

PHY-H-C-102-T: MECHANICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire, Bending moment, Cantilever, beam supported at the end and loaded at middle and its application to determine young's modulus, Searle's experiments. **(10 Lectures)**

Fluid Motion: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube, Mayer's equations, Rankine's methods for measurement of viscosity of gas. **(8 Lectures)**

Hydrodynamics: Equation of continuity and deduction of Euler's equation **(2 Lectures)**

Surface Tension: Surface tension and surface energy, angle of contact, principle of virtual work and its use to obtain expression for the pressure on two sides of curved liquid surface. Ripples and Gravity waves, Determination of surface tension by Ripple tank method and Quincke's method. **(10 Lectures)**

Central Force Motion: Motion of a particle under a central force field: two body problem. Kepler's Laws and their deduction. **(8 Lectures)**

Non-Inertial Systems: Inertial and Non-inertial frames of references, Concept of Centrifugal and Coriolis force. **(2 Lectures)**

Special Theory of Relativity: Galilean transformation, Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction. Time dilation. Simultaneity, Relativistic addition of velocity, Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Transformation of Energy and Momentum, Relativistic Doppler effect of light. **(20 Lectures)**

Reference Books:

1. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
2. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education.
4. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
5. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
6. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley.
7. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning.
8. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHY-H-C-101&102-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE): *The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To determine Young's modulus Y by bending of beam method.
2. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
3. To determine the elastic Constants of a wire by Searle's method.
4. To determine the value of g using Bar Pendulum.
5. To determine the value of g using Kater's Pendulum.
6. To verify the Binary and decimal arithmetic, Floating point numbers,
7. To find the Sum & average of a list of numbers using programming language 'C'
8. To find area of Circle using programming language 'C'

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

SEMESTER-II

PHY-H-C-203-T: ELECTRICITY AND MAGNETISM (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Electric Field and Electric Potential: Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations & its solution in Cartesian coordinates, The Uniqueness Theorem. Gauss' law in integral and differential form. Multipole expansion (monopole, dipole & quadrapole), energy density in an electric field. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(12 Lectures)**

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. **(8 Lectures)**

Transients: Growth and Decay of currents in LR, CR , LC and LCR circuits . **(6 Lectures)**

Magnetic Properties of Matter: Magnetization vector (**M).** Magnetic Intensity (**H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis. **(8 Lectures)**

Electrical Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. Anderson's bridge, De Sauty's Bridge and Owen's bridge & their vector diagram representation. Three phase electrical power supply, delta and star connections. **(12 Lectures)**

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Maximum Power Transfer theorem and Superposition Theorem. **(8 Lectures)**

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. **(6 Lectures)**

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH

2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
7. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
8. Electricity and Magnetism K K Tewary S. Chand and Company.

PHY-H-C-204-T: WAVES AND OPTICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Wave Motion: Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. **(6 Lectures)**

Oscillations: Free Vibration, Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(6 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends (Analytical Treatment), Plucked and Struck Strings. energy of vibrating string, transfer of energy. Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes. Lissajous Figures (1:1 and 1:2) and their uses. **(14 Lectures)**

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal waves in a fluid in pipe, Newton's Formula for Velocity of Sound, Laplace's Correction. **(6 Lectures)**

Interference: Division of amplitude and wavefront. Interference in Thin Films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(7 Lectures)**

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(8 Lectures)**

Fraunhofer diffraction: Single slit. Circular aperture and airy pattern, Resolving Power of a

telescope. Double slit. Plane transmission grating. Resolving power of grating. **(7 Lectures)**

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. **(6 Lectures)**

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
8. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5th Edn.,Reprint 2015, Sreedhar Publishers.
9. Geometrical and Physical Optics, P. K. Chakraborty, New Central Book Agancy (P) Ltd.
10. A Text Book of Optics, Dr. N. Subrahmanyam, Brijlal, Dr. M. N. Avadhanulu, S. Chand Publishers.

PHY-H-C-203&204-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE): *The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To determine an unknown Low Resistance using Carey Foster's Bridge.
3. To compare capacitances using De'Sauty's bridge.
4. To verify the Thevenin, Norton, Superposition and Maximum power transfer theorems.
5. To determine self inductance of a coil by Anderson's bridge.
6. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
7. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
8. To determine refractive index of the Material of a prism using sodium source.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

1. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

SEMESTER-III

PHY-H-C-305-T: MATHEMATICAL PHYSICS-II (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. **(14 Lectures)**

Special Functions: Legendre and Bessel Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. **(20 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. **(8 Lectures)**

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. **(4 Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. **(14 Lectures)**

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

PHY-H-C-306-T : THERMAL PHYSICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Zeroth and First Law of Thermodynamics: Zeroth Law of Thermodynamics & Concept of Temperature, First Law of Thermodynamics and its differential form, Internal Energy, Work Done during Isothermal and Adiabatic Processes, **(4 Lectures)**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(8 Lectures)**

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Entropy of a perfect gas. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations **(7 Lectures)**

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations: Clausius Clapeyron equation, Values of C_p-C_v for ideal and real gases, Tds Equations, **(4 Lectures)**

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(10 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(8 Lectures)**

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Joule- Thomson Cooling. Temperature of Inversion. **(12 Lectures)**

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Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press.
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.
7. Advanced Text Book on Heat, P. K. Chakrabarti, 10^{th} Edn., Reprint 2015, Sreedhar Prakashan.
8. Heat Thermodynamics and Statistical Physics, Brijlal, Dr. N. Subrahmanyam and P. S. Hemne, S. Chand Publishers.

PHY-H-C-307-T: ANALOG SYSTEMS AND APPLICATIONS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50*

words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.

Semiconductor Diodes: Derivation of Richardson's formula, P and N type semiconductors. Energy Level diagram. Conductivity and Mobility, Concept of Drift velocity. Static and Dynamic Resistance. Current equation Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **(10 Lectures)**

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. **(10 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β and relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(10 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(10 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(4 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(6 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators, Wien Bridge Oscillator. **(10 Lectures)**

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, TMH
5. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
6. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
7. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PHY-H-C-305P&306P&307-P (PRACTICAL) (06 Credits, 180 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 60 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
4. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To study V-I characteristics of PN junction diode, and Light emitting diode.
6. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
7. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
8. To study the characteristics of a Bipolar Junction Transistor in CE and CB configurations .
9. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

SEMESTER-IV

PHY-H-C-408-T: MATHEMATICAL PHYSICS-III (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex

Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Integration of a function of a complex variable. Cauchy's Inequality & Theorem. Cauchy's Integral formula. Laurent and Taylor's Theorem. Residues and Cauchy's Residue Theorem. **(22 Lectures)**

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(2 Lectures)**

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Fourier transform of trigonometric, Gaussian, finite wave train, Dirac delta function, Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transform with examples, Application of Fourier transforms to differential equations: one dimensional wave and diffusion/heat flow equations. **(18 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function. **(18 Lectures)**

Reference Books:

1. Mathematical Methods for Physicists and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
3. Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
5. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
6. Mathematical Physics H K Dass

PHY-H-C-409-T: ELEMENTS OF MODERN PHYSICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Quantum Mechanics: Blackbody Radiation: Quantum theory of Light; Photo-electric effect

and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them, two slit experiment with electrons, probability, wave amplitude and wave functions, Bohr Correspondence Principle **(12 Lectures)**

Position measurement-gamma ray microscope through experiment, Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle, Energy-time & Position-momentum uncertainty principle. **(10 Lectures)**

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(10 Lectures)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, Liquid Drop model: semi-empirical mass formula and binding energy. **(8 Lectures)**

Radioactivity: Stability of the nucleus; Law of radioactive decay; Decay constant, Mean life and half-life, successive disintegration; methods of measurement of half-life, spectra of emitters, Elementary idea of Alpha decay; Beta decay. **(8 Lectures)**

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. **(4 Lectures)**

Lasers: Spontaneous and Stimulated emissions. Einstein's A and B coefficients. Metastable states. Optical Pumping and Population Inversion. Three-Level laser system and He-Ne Laser and Ruby Laser. **(8 Lectures)**

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury 2017, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
6. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
7. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W.

Savin, 2nd Edn., Tata McGraw-Hill Publishing Co. Ltd.
8. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
9. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

PHY-H-C-410-T: DIGITAL SYSTEMS AND APPLICATIONS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(10 Lectures)**

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Karnaugh Map -Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Product of Sum Method **(10 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion.BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and their applications. **(10 Lectures)**

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement.Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder & Subtractor. **(6 Lectures)**

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(6 Lectures)**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(3 Lectures)**

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(5 Lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders, BCD to 7 segments **(6 Lectures)**

Conversion: Resistive network (weighted and R-2R ladder), accuracy and resolution, A/D conversion (successive approximation). **(4 Lectures)**

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHY-H-C-408-P & 409-P & 410-P (PRACTICAL) (06 Credits, 180 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 60 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. Measurement of Planck's constant using black body radiation and photo-detector
2. To determine the wavelength of laser source using diffraction of single slit.
3. To determine the wavelength of laser source using diffraction of double slits.
4. To design a switch (NOT gate) using a transistor.
5. To verify and design AND, OR, NOT and NOR gates using NAND gates.
6. To design a combinational logic system for a specified Truth Table.
7. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
8. To study Half Adder, Full Adder and 4-bit binary Adder.
9. To study Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To study a digital to analog converter (DAC).
11. To study the analog to digital convertor (ADC).

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
5. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.
6. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

7. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.

SEMESTER-V

PHY-H-C-511-T: QUANTUM MECHANICS AND APPLICATION (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities; Conditions for Physical Acceptability of Wave Functions. Normalization, eigenvalues and eigenfunctions. Expectation values of position and momentum. **(10 Lectures)**

Time independent Schrodinger equation- Time independent Schrodinger equation; General solution of the time independent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension. **(10 Lectures)**

Operators: Postulates of quantum mechanics, Position, momentum, Hamitonian,and Energy operators; eigenvalues and eigenfunctions, commutator of position and momentum operators **(6 Lectures)**

General discussion in an arbitrary potential- One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, one dimensional potential step, Quantum tunnelling & rectangular potential barrier, one-dimensional square well potential. **(10 Lectures)**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment, Zeeman effect: electron magnetic moment and magnetic energy, Gyromagnetic Ratio and Bohr Magneton. **(12 Lectures)**

Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na). **(12 Lectures)**

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill

2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer.
7. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
8. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
9. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
10. Quantum Pnhysics, H. C. Verma, 2018, Surya Publications,.
11. Quantum Mechanics, S. N. Biswas, Books & Allied (P) Ltd.
12. Advanced Quantum Mechanics ,Satya Prakash, Kedar Nath Ram Nath Publisher.
13. Introduction To Quantum Mechanics, Nikhil Ranjan Roy, Vikas Publishing.

PHY-H-C-512-T: SOLID STATE PHYSICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors.Lattice with a Basis, Unit Cell, Bravais lattice (2D &3D), Miller Indices. Reciprocal Lattice- properties and applications. Types of Lattices. Brillouin Zones-construction & applications. Diffraction of X-rays by Crystals, Bragg's Law, Laue's equation. **(14 Lectures)**

Lattice Vibrations and Phonons: Phonons of monatomic one dimensional lattice, Linear Diatomic Chains. Acoustical and Optical Phonons.Qualitative Description of the Phonon Spectrum in Solids.Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.T^3 law **(16 Lectures)**

Magnetic Properties of Matter: Dia-, Para-, and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic materials.Curie's law, Weiss's Theory of Ferromagnetism and Ferromagne tic Domains.Discussion of B-H Curve. Hysteresis and Energy Loss. **(12 Lectures)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability.Langevin-Debye equation. **(8 Lectures)**

Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility,

Hall Effect. **(10 Lectures)**

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
8. Solid State Physics, M.K. Mahan and P. Mahto, 2008, Bharti Bhawan.
9. Introduction to Solid State Physics , Arun Kumar, PHI Learning.

PHY-H-C-511-P & 512-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^{o}C) and to determine its band gap.
2. To determine the Hall coefficient of a semiconductor sample.
3. To study the V-I characteristics of a Zener diode
4. To study the use of Zener Diode as a voltage regulator.
5. To Study Zeeman effect with external magnetic field; Hyperfine splitting
6. To show the tunneling effect in tunnel diode using I-V characteristics.
7. To measure the Dielectric Constant of a dielectric Materials with frequency
8. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
9. To determine the refractive index of a dielectric layer using SPR
10. To study the PE Hysteresis loop of a Ferroelectric Crystal.
11. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

PHY- H-DSE-501A-T: PHYSICS OF DEVICES & INSTRUMENTS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO_2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode. **(14 Lectures)**

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. T and Pi section filters. Regulators, Line and load regulation, Short circuit protection **(12 Lectures)**

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **(10 Lectures)**

Multivibrators: Astable and Monostable Multivibrators using transistors. **(6 Lectures)**

Digital Data Communication Standards: Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. Basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK. **(18 lectures)**

Reference Books:

1. Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons.
2. Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
3. Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd.
4. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
5. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
6. Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.
7. Basic Electronics: Arun Kumar, Bharti Bhawan 2007.

PHY-H-DSE-501B-T EXPERIMENTAL TECHNIQUES (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Gaussian distribution. **(7 Lectures)**

Signals and Systems: Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise **(3 Lectures)**

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference **(4 Lectures)**

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Qualitative difference between Transducers and sensors. Types of sensors (Physical, Chemical and Biological), Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector **(21 Lectures)**

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(5 Lectures)**

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge. **(4 Lectures)**

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump & Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode). **(16 Lectures)**

Reference Books:

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI

Learning Pvt. Ltd.
3. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S.Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
5. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

PHY-H-DSE-501C-T: ASTRONOMY AND ASTROPHYSICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Basic Astronomical Parameters: Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars).

Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.

Stellar spectra: Spectral types and their temperature dependence, Hertzsprung-Russell Diagram. **(24 Lectures)**

Astronomical telescopes and techniques: Atmospheric Windows, Optical telescopes, Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST) **(8 Lectures)**

Stellar structure: Derivation of Virial Theorem for N bodies, Basic Equations of stellar structure, simple stellar models (Polytropic model, Derivation of the Lane-Emden equation, analytical solutions of the Lane-Emden equation) **(14 Lectures)**

The Sun and the Solar System: Solar Atmosphere, Solar Photosphere, Chromosphere, Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics, Origin of the Solar System (The Nebular Model, Tidal Forces, Planetary Rings and their formation); Extra- Solar Planets. **(8 Lectures)**

The Milky Way: Basic Structure and Properties of the Milky Way, Clusters of Galaxies (Virial theorem and Dark Matter), Hubble's Law **(6 Lectures)**

Reference Books:

1. An Introduction to Modern Astrophysics and Cosmology (Second Edition), B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co., 2006

2. Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory
3. Saunders College Publishing, 1998 Fundamental of Astronomy (Fifth Edition), H. Karttunen et al. Springer, 2007
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Publication, 2001
5. The Cosmic Perspective (Eighth Edition), J. O. Bennet, M. Donahue, N. Schneider &M. Voit, Pearson Publications, 2017
6. The Physical Universe: An Introduction to Astronomy, Frank Shu, Oxford University Press, 1985
7. Astrophysics: Stars and Galaxies, K. D. Abhyankar, Universities Press, 2001

PHY-H-DSE-502A-T:ADVANCED MATHEMATICAL PHYSICS (04 Credits, 60Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Linear Algebra: Vector Spaces: Vector Spaces over Fields of Real and Complex numbers. Examples. Vector space of functions.Linear independence of vectors.Basis and dimension of a vector space. Change of basis. Subspace. Isomorphisms. Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities. **(14 Lectures)**

Linear Transformations: Introduction. Identity and inverse.Singular and non-singular transformations.Representation of linear transformations by matrices. Similarity transformation. Linear operators. Adjoint of a linear operator.Hermitian operators and their matrix representation. Examples. Eigenvalues and eigenvectors of linear operators.Properties of eigenvalues and eigenvectors of Hermitian and unitary operators.Functions of Hermitian operators **(22 Lectures)**

Tensors: Symmetric and antisymmetric tensors. Change of basis: relation between coordinate basis vectors. Change of tensor components under change of coordinate system. Example: Inertial coordinates & bases in Minkowski space, Lorentz transformations as coordinate transformations, Elelctromagnetic tensor and change in its components under Lorentz transformations**.** **(12 Lectures)**

Variational Principle: Euler's Equation. Hamilton's Principle and the Euler-Lagrange equations of motion. Applications: motion of a simple pendulum, particle constrained to move on a hoop. **(12 Lectures)**

Reference Books:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
4. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
5. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
6. Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press

PHY-H-DSE-502B-T ATMOSPHERIC PHYSICS (04 Credits, 60Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms. **(12 Lectures)**

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. **(12 Lectures)**

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non-homogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration **(12 Lectures)**

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. **(12 Lectures)**

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption

and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. **(12 Lectures)**

Reference Books:

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PHY-H-DSE-502C-T: Biological Physics (04 Credits, 60Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Allometric scaling laws. **(6 Lectures)**

Molecules of life:Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.

Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways to be studied analytically and computationally. **(18 Lectures)**

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Entropic forces: Osmotic pressure; polymer elasticity**.**

Chemical forces: Self assembly of amphiphiles. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis. **(22 Lectures)**

Ecosystem and Biosphere: Foodwebs. Feedback cycles and self sustaining ecosystems. **(5 Lectures)**

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples. **(9 Lectures)**

Reference Books:

1. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004)
2. Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
3. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
4. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Phy-H-DSE-501A/B/C P & 502A/B/C-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design an Astable multivibrator of given specifications using transistor.
10. To study envelope detector for demodulation of AM signal.
11. To study the characteristics of a Thermostat and determine its parameters.
12. To plot the frequency response of a microphone.
13. To design and analyze the Clippers and Clampers circuits using junction diode.
14. Analysis of satellite data and plotting of atmospheric parameters using radio occultation technique.
15. Numerical Simulation for atmospheric waves using dispersion relations with the help of Scilab/C^{++}
    (a) Atmospheric gravity waves (AGW)
    (b) Kelvin waves
    (c) Rossby waves, and mountain waves
16. Offline and online processing of radar data with the help of Scilab/C^{++}
    (a) VHF radar,
    (b) X-band radar, and
    (c) UHF radar

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics : Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.

4. Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
5. PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India
6. Electronic circuits: Handbook of design and applications, U.Tietze and C.Schenk, 2008, Springer
7. Basic Electronics:A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill
8. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, 2005, PHI Learning.
9. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996.
10. The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3rd edn. 2002.
11. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004.
12. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014.

SEMESTER-VI

PHY-H-C-613-T: ELECTROMAGNETIC THEORY (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Maxwell Equations: Derivation of Maxwell's field equations. Displacement Current. Boundary Conditions at Interface between Different Media**.** **(10 Lectures)**

EM Wave Propagation in Unbounded Media: Propagation of EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Poynting Theorem and Poynting Vector. **(15 Lectures)**

EM Wave in Bounded Media: Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. **(10 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Uniaxial and Biaxial Crystals. Double Refraction. Polarization by Double Refraction.Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave

and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light. **(15 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization.Fresnel's Theory of optical rotation.Calculation of angle of rotation.Experimental verification of Fresnel's theory. Specific rotation. **(10 Lectures)**

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill.
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning.
6. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.
7. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
8. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
9. Electromagnetic Theory, Chopra and Agarwal, K. Nath & Co., Meerut.
10. Electromagnetic Theory and electrodynamics Satyaprakash, , Kedar Nath Ram Nath Publishers
11. Electricity and Magnetism, K.K.Tiwari, S Chand Publishers.
12. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press.

PHY-H-C-614-T: STATISTICAL MECHANICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Boltzmann entropy relation, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur-Tetrode equation. Ideas of ensembles, micro-canonical, canonical and grand canonical ensembles. and expression for distribution function, partition function and calculation of themodynamic quantities. **(25 Lectures)**

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(10 Lectures)**

Bose-Einstein Statistics: Bose -Einstein distribution law, Thermodynamic functions of a

strongly Degenerate Bose Gas, Bose derivation of Planck's law. **(12 Lectures)**

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal. **(13 Lectures)**

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.
7. Statistical Mechanice, B. K. Agarwal and Melvin Eisner, 2nd Edn. ,2007, New Age International Publishers.

PHY-H-C-613-P & 614-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study the reflection, refraction of microwaves
5. To study Polarization and double slit interference in microwaves.
6. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
7. To verify the Stefan`s law of radiation and to determine Stefan's constant.
8. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

PHY-H-DSE-603A-T CLASSICAL DYNAMICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Classical Mechanics of Point Particles: Generalised coordinates and velocities. Hamilton's Principle, Lagrangian and Euler-Lagrange equations. Applications to simple systems such as coupled oscillators. Canonical momenta & Hamiltonian.Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, particle in a central force field. Poisson brackets. Canonical transformations. **(25 Lectures)**

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction & twin paradox. Four-vectors: space-like, time-like & light-like. Four-velocity and acceleration.Four-momentum and energy-momentum relation. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of **E** and **B**. Electric and magnetic fields due to a uniformly moving charge. Equation of motion of charged particle & Maxwell's equations in tensor form. Motion of charged particles in external electric and magnetic fields. **(35 Lectures)**

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
7. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
8. Introduction to Classical Mechanice, Nikhil ranjan Roy, Vikash Publishing.

PHY-H-DSE-603B-T: COMMUNICATION SYSTEM (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. **(4 Lectures)**

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector),Qualitative idea of Super heterodyne receiver. **(12 Lectures)**

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. **(9 Lectures)**

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation,Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). **(10 Lectures)**

Introduction to Communication and Navigation systems: Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earthstation. Uplink and downlink. **(10 Lectures)**

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only). **(15 Lectures)**

Reference Books:

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
4. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
5. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill.
6. Communication Systems, S. Haykin, 2006, Wiley India.
7. Electronic Communication system, Blake, Cengage, 5th edition.

8. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press.

PHY-H-DSE-603C-T: APPLIED DYNAMICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems.
Examples of dynamical systems –Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bistability. **(22 Lectures)**

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.

Nonlinear time series analysis and chaos characterization: Detecting chaos from Return map, Power spectrum, Autocorrelation, Lyapunov exponent, Correlation dimension. **(22 Lectures)**

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streaklines. **(16 Lectures)**

Reference Books

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007.
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
4. An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge Univ. Press, 2002.
5. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

PHY-H-DSE-604A-T: NUCLEAR & PARTICLE PHYICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Structure and properties of the nucleus: Structure of nucleus, Discovery of the nucleus, composition. Basic properties; charge, mass, size, spin, magnetic moment, electric quadruple moment, binding energy, binding energy per nucleon and its observed variation with mass number of the nuclei. **(8 Lectures)**

Nuclear Force: Two nucleon system, deuteron problem, binding energy. **(6 Lectures)**

Nuclear detectors: Detectors for charged particles; ion chamber, GM counter, resolving time, cloud chamber and bubble chamber. **(9 Lectures)**

Accelerator: Need for accelerators, linear accelerators, cyclotron, synchrocyclotron. **(8 Lectures)**

Radioactivity: Geiger-Nuttal Law, Gamow's theory of α decay. **(4 Lectures)**

Nuclear reactions: Rutherford's experiments of nuclear transmutation, conservation theorems, Q-value, threshold energy, cross-section of nuclear reactions. **(9 Lectures)**

Cosmic rays and elementary particles: Discovery of cosmic rays: hard and soft components, discovery of muon, pion, heavy mesons and hyperons, mass and life-time determination for muon and pion. Primary cosmic rays: Extensive air showers, solar modulation of primary cosmic rays, effect of earth's magnetic field on the cosmic ray trajectories. **(16 Lectures)**

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane Wiley India Pvt. Ltd., 2008.

2. Concepts of Nuclear Physics by Bernard L. Cohen. Tata Mcgraw Hill, 1998.
3. Introduction to the physics of nuclei & particles, R.A. Dunlap, Thomson Asia, 2004.
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde,IOP- Institute of Physics Publishing, 2004.
8. Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2000.
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007.
10. Theoretical Nuclear Physics, J.M. Blatt & V. F.Weisskopf, Dover Pub.Inc., 1991.
11. Nuclear Physics, S. N. Ghosal, S. Chand Publisher, 1994.
12. Nuclear Physics, D. C. Tayal, 2011, Himalaya Publishing House.

PHY-H-DSE-604B-T: DIGITAL SIGNAL PROCESSING (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. **(10 Lectures)**

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The *z*-Transform:** Bilateral (Two-Sided) *z*-Transform, Inverse *z*- Transform, Relationship Between *z*-Transform and Discrete-Time Fourier Transform, *z*- plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the *z*-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations. **(15 Lectures)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. **(5 Lectures)**

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. **(10 Lectures)**

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (*WN*), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. **(5 Lectures)**

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.
Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. **(15 Lectures)**

Reference Books

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
6. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

PHY-H-DSE-604C-T: NANO MATERIALS AND APPLICATIONS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50*

words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.

Nanoscale Systems: Density of states (1-D,2-D,3-D). Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **(10 Lectures)**

Synthesis of Nanostructure Materials: Metals, Metal Oxide, Carbon based nanomaterials CNT, C_{60}, graphene. Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Chemical vapor deposition (CVD).Sol-Gel. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots. **(8 Lectures)**

Characterization: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **(8 Lectures)**

Optical properties: Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. **(14 Lectures)**

Electron transport: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. **(6 Lectures)**

Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). **(14 Lectures)**

Reference books:

1. C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology ,Wiley India Pvt. Ltd.
2. S.K. Kulkarni, Nanotechnology: Principles & Practices ,Capital Publishing Company
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology ,PHI Learning Private Limited..
4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology ,John Wiley and Sons.

PHY-H-DSE-603A/B/C-P & 604A/B/C-P (PRACTICAL) (04 Credits, 120 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 40 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
2. To determine the wavelength of sodium source using Michelson's interferometer.
3. To determine wavelength of sodium light using Fresnel Biprism.
4. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.
5. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
6. Measurement of viscosity of liquid by oscillating disc method.
7. To determine value of Boltzmann constant using V-I characteristic of PN diode.
8. To determine work function of material of filament of directly heated vacuum diode.
9. To determine value of Planck's constant using LEDs of at least 4 different colours.
10. To study envelope detector for demodulation of AM signal.
11. To study ASK, PSK and FSK modulators.
12. To study AM Transmitter and Receiver.
13. To study FM Transmitter and Receiver.
14. To design an Amplitude Modulator using Transistor.
15. To study Pulse Amplitude Modulation (PAM).
16. To determine the coupling coefficient of coupled pendulums.
17. To determine the coupling coefficient of coupled oscillators.
18. To determine the coupling and damping coefficient of damped coupled oscillator.
19. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes using Scilab/Octave/Maple.
20. Computational Flow visualization using Scilab/Octave/Maple - streamlines, pathlines, Streaklines.
21. Using Scilab/Matlab, write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x\ n\ = 0.8^{\,n}\ u(n)$ for $0 \leq n \leq 50$.
22. To study the effect of size on color of nanomaterials.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.

4. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
5. Electronic Communication system, Blake, Cengage, 5th edition.
6. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
7. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
8. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
9. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer.
10. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
11. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
12. C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
13. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).

GENERIC ELECTIVE PHYSICS (FOR STUDENTS OTHER THAN PHYSICS HONOURS STUDENTS)

SEMESTER – I

PHY-H-GE-101-T: MECHANICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions).Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Vector Analysis: Triple Scalar product, Triple Vector product, gradient, divergence, Curl and their physical significance, scalar and vector fields, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem. **(12 Lectures)**

Ordinary Differential Equations: 1st order homogeneous differential equations. 2^{nd}order homogeneous differential equations with constant coefficients. **(8 Lectures)**

Central force field: Motion of a particle in a central force field –two body problem. Kepler's Laws and their deduction. **(5 Lectures)**

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. **(5 Lectures)**

Elasticity: Elastic constants and their interrelations, Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion, Torsional pendulum. **(12 Lectures)**

Fluids: Surface Tension: Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature. **(10 Lectures)**

Special Theory of Relativity: Galilean transformations . Postulates of Special Theory of Relativity.Lorentz transformation, Length contraction.Time dilation. Relativistic addition of velocities. **(8 Lectures)**

Reference Books:

1. Mathematical Physics, H K Das and Dr. Rama Verma, S. Chand and Company Limited.
2. Mathematical Physics, B D Gupta, Vikash Publishing House, 4^{th} edition.
3. Mathematical Physics, B S Rajput, Pragati Prakashan.

4. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jonesand Bartlett Learning.
5. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
6. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.
7. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
8. Physics – Resnick, Halliday& Walker 9/e, 2010, Wiley.
9. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
10. Elements of Properties of Matter, D. S. Mathur, S. Chand Publication.

PHY-H-GE-101-P (PRACTICAL) (02 credits, 30 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 20 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical PHYsics, InduPrakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.
4. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
5. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

SEMESTER – II

PHY-H-GE-202-T: ELECTRICITY & MAGNETISM (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions).Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge,

uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge,
Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser.Energy per unit volume in electrostatic field.
Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(25 Lectures)**

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro-magnetic materials. **(12 Lectures)**

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(8 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves. **(15 Lectures)**

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
6. Electromagnetic Theory and electrodynamics Satyaprakash, , Kedar Nath Ram Nath Publishers
7. Electricity and Magnetism, K.K.Tiwari, S Chand Publishers.

PHY-H-GE-202-P (PRACTICAL) (02 credits, 30 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 20 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. To compare capacitances using De'Sauty's bridge.
3. To study the Characteristics of a Series RC Circuit.
4. To study a series LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
5. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
6. To determine a Low Resistance by Carey Foster's Bridge.
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum Power Transfer Theorems.

Reference Books

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed.2011, KitabMahal.
3. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
4. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

SEMESTER – III

PHY-H-GE -303-T: THERMAL PHYSICS AND STATISTICAL MECHANICS (04Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions).Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Laws of Thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics (statement only), Unattainability of absolute zero. **(22 Lectures)**

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(10 Lectures)**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path, Transport Phenomena: Viscosity, Conduction and Diffusion, Law of equipartition of energy and its applications to specific heat of gases; mono-atomic and diatomic gases. **(10 Lectures)**

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction from Planck's law-Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law. **(6 Lectures)**

Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity, Quantum statistics: Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures)**

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
6. Advanced Text Book on Heat, P. K. Chakrabarti, 10th Edn., Reprint 2015, Sreedhar Prakashan.
7. Heat Thermodynamics and Statistical Physics, Brijlal, Dr. N. Subrahmanyam and P. S. Hemne, S. Chand Publishers.

PHY-H-GE -303-P (PRACTICAL) (02 Credits, 30 Lectures)

Instruction to Question Setter for End Semester Practical Examination (ESE):*The questions in practical examination will be of equal to 20 marks and will be of 3 hours duration. Distribution of marks in practical paper of an end-semester examination will be of 60% in performance of experiment, 20% in record/note book and 20% in viva-voce.*

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

Reference Books:

1. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
2. A Laboratory Manual of PHYsics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.
3. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
4. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

SEMESTER – IV

PHY-H-GE-404-T: WAVES & OPTICS (04 Credits, 60 Lectures)

Instruction to Question Setter for End Semester Examination (ESE): *There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions).Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.*

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition

Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **(6 Lectures)**

Waves Motion: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. **(8 Lectures)**

Sound: Forced vibrations and resonance, Fourier's Theorem - Application to saw tooth wave and square wave Acoustics of buildings, Reverberation and time of reverberation - Absorption coefficient - Sabine's formula. **(10 Lectures)**

Interference: Interference: Division of amplitude and division of wavefront. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **(10 Lectures)**

Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes. **(5 Lectures)**

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Plane Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(14 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(7 Lectures)**

Reference Books:

1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
4. University PHYsics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley
11. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing,
12. Geometrical and Physical Optics, P. K. Chakraborty, New Central Book Agancy (P) Ltd.
13. Introduction to Geometrical and Physical Optics, B. K. Mathur, Gopal Printing.
14. A Text Book on Light, B. Ghosh and K. G. Mazumdar, 5th Edn.,Reprint 2015, Sreedhar Publishers.
15. A Text Book of Optics, Dr. N. Subrahmanyam, Brijlal, Dr. M. N. Avadhanulu, S. Chand Publishers.

PHY-H-GE-404-P (PRACTICAL)(02 Credits, 30 Lectures)

1. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law.
2. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
3. To determine the Refractive Index of the Material of a Prism using Sodium Light.
4. To determine Dispersive Power of the Material of a Prism using Mercury Light
5. To determine the value of Cauchy Constants.
6. To determine the Resolving Power of a Prism.

7. To determine wavelength of sodium light using Fresnel Biprism.
8. To determine wavelength of sodium light using Newton's Rings.
9. To determine the wavelength of Laser light using Diffraction of Single Slit.
10. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
11. To determine the Resolving Power of a Plane Diffraction Grating.

Reference Books:

1. Advanced Practical PHYsics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
3. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company.

Binod Bihari Mahto Koyalanchal University, Dhanbad

End-Semester Examination xxxx(Session: xxxx-xx)

Subject/Code:

Full Marks: 80 Pass Marks: 32 Time:3Hours

General Instructions:

Candidates are required to give their answers in their own words as far as practicable.

The Questions are of equal value.

Answer any five questions of the following in which Q.1 is compulsory.

Group A

1. (A) Multiple Choice Questions (1x8=08)

(i) ……..
(ii) ……..
(iii) ……..
(iv) ……..
(v) ……..
(vi) ……..
(vii) ……..
(viii) ……..

(B) Short answer type questions (4x2=08)

(a) ……..
(b) ……..

Group B

(Long answer type questions)

Answer any four of the following. (16x4=64)

2. ……..
3. ……..
4. ……..
5. ……..
6. ……..
7. ……..
8. ……..
9. Short notes type questions (8x2=16)

(a) ……..
(b) ……..
(c) ……..
(d) ……..

……x……

Binod Bihari Mahto Koyalanchal University, Dhanbad

End-Semester Examination xxxx (Session: xxxx-xx)

Subject/Code:

Full Marks: 60 Pass Marks: 24 Time: 3Hours

General Instructions:

Candidates are required to give their answers in their own words as far as practicable.

The Questions are of equal value.

Answer any five questions of the following in which Q.1 is compulsory.

Group A

1. (A) Multiple Choice Questions (1x6=06)

(i) ……..

(ii) ……..

(iii) ……..

(iv) ……..

(v) ……..

(vi) ……..

(B) Short answer type questions (3x2=06)

(a) ……..

(b) ……..

Group B

(Long answer type questions)

Answer any four of the following. (12x4=48)

2. ……..

3. ……..

4. ……..

5. ……..

6. ……..

7. ……..

8. ……..

9. Short notes type questions (6x2=12)

(a) ……..

(b) ……..

(c) ……..

(d) ……..

……x……

Binod Bihari Mahto Koyalanchal University, Dhanbad

End-Semester Examination xxxx (Session: xxxx-xx)

Subject/Code:

Full Marks: 40 Pass Marks: 16 Time: 2Hours

General Instructions:

Candidates are required to give their answers in their own words as far as practicable.
The Questions are of equal value.

Answer any five questions of the following in which Q.1 is compulsory.

Group A

1. (A) Multiple Choice Questions (1x4=04)

(i) ……..
(ii) ……..
(iii) ……..
(iv) ……..

(B) Short answer type questions (2x2=04)

(a) ……..
(b) ……..

Group B

(Long answer type questions)

Answer any four of the following. (8x4=32)

2. ……..
3. ……..
4. ……..
5. ……..
6. ……..
7. ……..
8. ……..
9. Short notes type questions (4x2=8)

(a) ……..
(b) ……..
(c) ……..
(d) ……..

……x……