THE UNIVERSITY OF BURDWAN

SYLLABUS FOR THREE-YEAR B.Sc. GENERAL PROGRAMME IN PHYSICS

UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

(With effect from the session 2017-2018)

Details of Courses under Undergraduate Program (B.Sc.)

Course   ***Credits**

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	Theory+Practical	Theory+Tutorials
I. Core Course (12 Papers)	12X4= 48	12X5=60

04 Courses from each of the 03 disciplines of choice

Core Course Practical / Tutorial* **(12 Practical/ Tutorials)**	12X2=24	12X1=12

04 Courses from each of the 03Disciplines of choice

II. Elective Course (6 Papers)	6x4=24	6X5=30

Two papers from each discipline of choice including paper of interdisciplinary nature.

Elective Course Practical/Tutorials **(6 Practical / Tutorials)**	6X2=12	6X1=6

Two Papers from each discipline of choice including paper of interdisciplinary nature

III. Ability EnhancementCourses

1. **Ability Enhancement Compulsory Course (2 Papers)**

AECC- 1 : Environmental Studies	4X1=4	4X1=4
AECC- 2: Communicative English/ MIL	2X1=2	2X1=2

2. **Skill Enhancement Course** (Skill Based)

	4X2=8	4X2=8

(4 Papers of 2 credits each)

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Totalcredit=122	**Total credit=122**

Proposed scheme for choice based credit system in B. Sc. with Physics

SEM.	CORE COURSE	Ability Enhancement CompulsoryCourse (AECC)	Skill Enhancement Course (SEC)	Discipline Specific Elective (DSE)
I	CC- 1A: Mechanics CC- 2A CC- 3A	AECC- 1: Environmental Studies		
II	CC-1B: Electricity and Magnetism CC- 2B CC- 3B	AECC- 2: Communicative English/ MIL		
III	CC-1C : Thermal Physics and Statistical Mechanics CC- 2C CC- 3C		SEC-1	
IV	CC-1D: Waves and Optics CC- 2D CC- 3D		SEC -2	
V			SEC -3	DSE-1 A DSE-2 A DSE-3 A
VI			SEC -4	DSE-1 B DSE-2 B DSE-3 B

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course (AECC -1)	Environmental Studies	4
	Core course-1A (Theory)	Mechanics	4
	Core Course-1A: Practical/Tutorial	Mechanics Lab	2
	Core course-2A (Other discipline)		6
	Core Course-3A (Other discipline)		6
II	Ability Enhancement Compulsory Course (AECC- 2)	Communicative English/ MIL	2
	Core course-1B (Theory)	Electricity and Magnetism	4
	Core Course-1B Practical/Tutorial Core course-2B (Other discipline)	Electricity and Magnetism Lab	2 6
	Core Course-3B (Other discipline)		6
III	Core course-1C (Theory)	Thermal Physics and Statistical Mechanics	4
	Core Course-1C Practical/Tutorial	Thermal Physics and Statistical Mechanics Lab	2
	Core course-2C (Other discipline)		6
	Core Course-3C (Other discipline)		6
	Skill Enhancement Course -1	Renewable Energy and Energy Harvesting	2
IV	Core course-1D (Theory)	Waves and Optics	4
	Core Course-1D Practical/Tutorial	Waves and Optics Lab	2
	Core course-2D (Other discipline)		6
	Core course-3D (Other discipline)		6
	Skill Enhancement Course -2	Weather Forecasting	2
V	Discipline Specific Elective -1A	Elements of Modern Physics OR Nuclear and Particle Physics	6
	Discipline Specific Elective -2A	DSE-2A	6
	Discipline Specific Elective -3A Skill Enhancement Course -3	DSE-3A Computational Physics Skills	6 2
VI	Discipline Specific Elective -1B	Quantum Mechanics OR Digital, Analog and Instrumentation	6
	Discipline Specific Elective -2B	DSE-2B	6
	Discipline SpecificElective – 3B Skill Enhancement Course - 4	DSE-3B Electrical Circuits and Network Skills	6 2
Total Credit			122

Physics

1 credit = 1 hour/week for theory; 2 hours/week for practical

Core papers Physics (Credit: 06 each):

CC- 1A	Mechanics	Semester- I
CC- 1B	Electricity and Magnetism	Semester- II
CC- 1C:	Thermal Physics and Statistical Mechanics	Semester- III
CC- 1D:	Waves and Optics	Semester- IV

Discipline Specific Elective papers (Credit: 06 each) (DSE 1A, DSE 1B): (One each from Semesters – V and VI)

DSE- 1:	Elements of Modern Physics OR Nuclear and Particle Physics	Semester- V
DSE- 2:	Quantum Mechanics OR Digital, Analog and Instrumentation	Semester- VI

Skill Enhancement Course (Credit: 02 each)- SEC 1 to SEC 4

SEC- 1.	Renewable Energy and Energy harvesting	Semester- III
SEC-2.	Weather Forecasting	Semester- IV
SEC- 3.	Computational Physics Skills	Semester- V
SEC- 4.	Electrical circuits and Network Skills	Semester- VI

For Papers having practical, distribution of 75 marks be as follows:

i) <u>Class Attendance cum Internal Assessment</u> : 20% of 75 marks = 15 marks of which 5 marks be reserved for theoretical class attendance in the following manner:

> Attendance 50% & above but below 60% - 2 marks Attendance 60% & above but below 75% - 3 marks
> Attendance 75% & above but below 90% - 4 marks
> Attendance 90% & above   - 5 marks

and 10 marks be reserved for class test/assignment/seminar (theoretical-5 & practical-5).

ii) 20 marks be allotted for <u>Semester-end- Practical Examination</u> of each paper, distribution of which may be as under:
  a) Lab. Note Book : 05   Marks
  b) Viva- voce   : 05 Marks
  c) Experiment   : 10 marks

iii) 40 marks be allotted for <u>Semester-end-Theoretical Examination</u> of each paper (Duration of Exam: 2 hours), distribution of which may be as under:
  a) Answer 05 questions out of 08 carrying 02 marks each   = 05x02 = 10
  b) Answer 02 questions out of 04 carrying 05 marks each   =02x05 = 10
  c) Answer 02 questions out of 04 carrying 10 marks each   =02x10 = 20

However, questions, carrying 5 or 10 marks, need not necessarily to be a single question.

For paper, having tutorial (PHY-DSE-2), distribution of 75 marks be as follows:

i) <u>Class Attendance cum Internal Assessment</u> : 20% of 75 marks = 15 marks of which 5 marks be reserved for class attendance (both theoretical + tutorial) in the following manner:

Attendance 50% & above but below 60% - 2 marks Attendance 60% & above but below 75% - 3 marks

Attendance 75% & above but below 90% - 4 marks

Attendance 90% & above   - 5 marks

and 10 marks be reserved for class test/ assignment/ seminar (theoretical- 5 & tutorial - 5). Minimum 15 classes be allotted for tutorial portion.

ii)   In the Semester-end- Examination of each paper (Duration of Exam : 3 hours), Question Paper be set for 60 marks, distribution of which may be as under:

a) Answer 10 questions out of 15 carrying 02 marks each = 10x 02 =20
b) Answer 04 questions out of 06 carrying 05 marks each = 04x 05 =20
c) Answer 02 questions out of 04 carrying 10 marks each = 02x 10 =20

However, questions, carrying 05 or 10 marks, need not necessarily to be a single question.

For each SEC paper, distribution of 50 marks be as follows:

i)   Internal Assessment: 20% of 50 marks = 10 marks be reserved for class test/ assignment/ seminar.

ii) 40 marks be allotted for Semester-end-Theoretical Examination of each paper (Duration of Exam : 2 hours), distribution of which may be as under:

a) Answer 05 questions out of 08 carrying 02 marks each = 5x2 = 10
b) Answer 02 questions out of 04 carrying 05 marks each = 2x5 = 10
c) Answer 02 questions out of 04 carrying 10 marks each = 2x10 = 20

However, questions, carrying 5 or 10 marks, need not necessarily to be a single question.

Mode of Practical Examination

Centre: Concerned College

Convener: The convener for each practical paper is to be nominated by the UGBS.

Examiners: One internal examiner of the concerned college and one external examiner are to be nominated by the UGBS. However, if any nominated external examiner does not accept the offer due to unavoidable circumstances to be substantiated by the document through proper channel, the Chairman of the UGBS can nominate the external examiner with the consultation of the convener.

CC- 1A: MECHANICS   (Credits: Theory - 04, Practical - 02)

F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures

 Vectors: Vector algebra, Scalar and vector products, Derivatives of a vector with respect to a parameter.   **(4Lectures)**
 Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.   **(6Lectures)**
 Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.   **(10Lectures)**
 Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.   **(6Lectures)**
 RotationalMotion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.   **(5Lectures)**
 Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).   **(8 Lectures)**
 Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.   **(6 Lectures)**
 Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - 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- Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method   **(8 Lectures)**
 Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.   **(7Lectures)**

Reference Books:
1.   University Physics. F W Sears, M W Zemansky and H D Young13/e,1986.Addison-Wesley
2.   MechanicsBerkeleyPhysicscourse,v.1: Charles Kittel, et.Al.2007,Tata McGraw-Hill.
3.   Physics–Resnick, Halliday &Walker 9/e, 2010,Wiley
4.   Engineering Mechanics, Basudeb Bhattacharya, 2^{nd}edn., 2015, Oxford University Press
5.   University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

CC- 1A: MECHANICS
Practical:
  1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
  2. To determine the Moment of Inertia of a Flywheel/ regular shaped objects.
  3. To determine Young's Modulus by flexure method.
  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 / dynamical method.

6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar/Kater's Pendulum.
8. To determine the coefficient of viscosity by Poiseuille's method.
9. To study the Motion of a Spring and calculate (a) Spring Constant (b)Value of 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, 4[th]Edition, reprinted 1985, Heinemann Educational Publishers.
3. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11[th]Edition, 2011, Kitab Mahal, New Delhi.

Semester - II

CC-1B: ELECTRICITY AND MAGNETISM

(Credits: Theory - 04, Practical - 02)   F.M. = 75 (Theory - 40, Practical – 20,   Internal Assessment – 15)

Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**

Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).   **(12Lectures)**
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, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor.
Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.   **(22 Lectures)**
Magnetism: Magnetostatics: Biot-Savart's law & 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. **(10 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.   **(6 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 dielectricmedium, transverse nature of EM waves, polarization.   **(10 Lectures)**

Reference Books:
1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education..
2. Electricity and 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.

CC-1B: ELECTRICITY AND MAGNETISM

Practical:
1. To use a Multimeter for measuring (a)Resistances, (b)AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii) Measurement of CDR
3. To compare capacitances using De'Sauty's bridge.
4. To study the Characteristics of a Series RC Circuit.
5. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
6. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
7. To determine a Low Resistance by Carey Foster's Bridge.
8. To verify the Thevenin and Norton theorem
9. To verify the Superposition, and Maximum Power Transfer Theorem
10. To determine the horizontal component of earth's magnetic field.
11. To determine the resistance of a suspended coil galvanometer by half deflection method and hence calculate the sensitivity of the galvanometer.

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, Indu Prakash and Ramakrishna, 11[th]Edition, 2011, Kitab Mahal, New Delhi.
3. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4[th]Edition, reprinted 1985, Heinemann Educational Publishers

CC-1C: THERMAL PHYSICS AND STATISTICAL MECHANICS
(Credits: Theory - 04, Practical - 02)

F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar)
– 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**
Laws of Thermodynamics:

Thermodynamic Description of system: 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 C_P & C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

                                                            (22Lectures)
Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (C_P – C_V), C_P/C_V, TdS equations.   **(10 Lectures)**
Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.   **(10Lectures)**
Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.   **(6 Lectures)**
Statistical Mechanics: Phase space, Macro state and Micro state, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein Distribution law - photon gas - comparison of three statistics.   **(12Lectures)**

Reference Books:
1. ThermalPhysics, 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. Heat and Thermodynamics, M.W.Zemasky and R.Dittman,1981, McGraw Hill
5. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears & G.L.Salinger. 1988, Narosa
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
7. Thermal Physics, A.Kumar and S.P.Taneja, 2014, R.Chand Publications.

CC-1C: THERMAL PHYSICS AND STATISTICALMECHANICS
Practical:
1. Measurement of Planck's constant using black body radiation.
2. To determine Stefan's Constant.
3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
4. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

5. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
6. To determine the coefficient of linear expansion by optical lever method.
7. To determine the pressure coefficient of air by constant volume method.
8. To determine the coefficient of linear expansion by travelling microscope.
9. To determine the coefficient of thermal conductivity of a good conductor by Searle's method.

Reference Books:
1. Advanced Practical Physics for students, B.L.Flint & 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, 11thEdition, 2011,Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985,Vani Publication.

Skill Enhancement Course
SEC-1: RENEWABLE ENERGY AND ENERGY HARVESTING (Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Theory (Class Test/ Assignment/ Seminar)] – 10

Theory: **30 Lectures**
The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

Fossil fuels and Alternate Sources of energy: Fossil fuels and Nuclear Energy, their imitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydro electricity.
                                                                                    (3Lectures)
Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.   **(6Lectures)**
Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
                                                                                    (3Lectures)
Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.   **(3Lectures)**
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.   **(2Lectures)**
Geothermal Energy: Geothermal Resources, Geothermal Technologies.   **(2Lectures)**
Hydro Energy: Hydro power resources, hydro power technologies, environmental impact of hydro power sources.   **(2Lectures)**
Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power
                                                                                    (4Lectures)

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications **(2Lectures)**
Carbon captured technologies, cell, batteries, power consumption **(2Lectures)**
Environmental issues and Renewable sources of energy, sustainability. **(1 Lecture)**

Demonstrations and Experiments
1. Demonstration of Training modules on Solar energy, wind energy,etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books:
1. Non-conventional energy sources- G.DRai- Khanna Publishers, New Delhi
2. Solar energy – M P Agarwal- S Chand and Co. Ltd.
3. Solar energy- Suhas P Sukhative Tata McGraw-Hill Publishing Company Ltd.
4. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 2004, Oxford University Press in association with The Open University.
5. Dr.P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. J.Balfour, M.Shaw and S.Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
7. http://en.wikipedia.org/wiki/Renewable_energy

Semester - IV

CC- 1D: WAVES AND OPTICS
(Credits: Theory - 04, Practical - 02)

F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats)
(4 Lectures)
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**
Waves Motion-General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves.Spherical waves, Wave intensity.
(7Lectures)
Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure – Application to spherical and cylindrical drops and bubbles-variation of surface tension with temperature - Jaegar's method. Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of a liquid with temperature lubrication. Physics of low pressure - production and measurement of low pressure- Rotary pump- Diffusion pump - Molecular pump - Knudsen absolute gauge - penning and pirani gauge – Detection of leakage.
(6Lectures)
Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical

notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula – measurement of reverberation time- Acoustic aspects of halls and auditoria. **(6 Lectures)**

Wave Optics: Electromagnetic nature of light. Definition and Properties of wavefront. Huygens Principle. **(3Lectures)**

Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. 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'sInterferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index and Visibility offringes. **(3 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; Double Slit.Multiple slits & 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. **(14Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(5Lectures)**

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 Publication
4. University Physics. F W Sears, M W Zemansky and H D Young 13/e, 1986. Addison-Wesley

CC-1D: WAVES AND OPTICS
Practical:
1. To determine the angle of prism by (i) Rotating telescope or (ii) Rotating prism method.
2. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
3. To determine Dispersive Power of the Material of a given Prism using Mercury Light
4. To determine the value of Cauchy Constants of a material of a prism.
5. To determine the Resolving Power of a Prism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine the diameter of a thin wire by Diffraction.
8. To determine wavelength of Sodium light using plane diffraction Grating.
9. To determine the Resolving Power of a Plane Diffraction Grating.
10. To determine the refractive index of a liquid by travelling microscope.
11. To determine the focal length of a concave lens by combination method.

Reference Books:
1. Advanced Practical Physics for students, B.L.Flint & 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, Indu Prakash and Ramakrishna, 11[th]Edition, 2011, Kitab Mahal, New Delhi.

Skill Enhancement Course

SEC-2: WEATHER FORECASTING   **(Credits: 02)**
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Theory (Class Test/ Assignment/ Seminar)] – 10

Theory: **30 Lectures**

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anti cyclones: its characteristics.   **(9Lectures)**
Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.   **(4Lectures)**
Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.   **(3 Lectures)**
Climate and Climate Change: Climate:its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.   **(6Lectures)**
Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.   **(8Lectures)**

    Demonstrations and Experiments:
1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
    (a) To calculate the sunniest time of the year.
    (b) To study the variation of rain fall amount and intensity by wind direction.
    (c) To observe the sunniest/driest day of th eweek.
    (d) To examine the maximum and minimum temperature throughout the year.
    (e) To evaluate the relative humidity of the day.
    (f) To examine the rainfall amount monthwise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and nonaviation)

    Reference books:
1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Handbook, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R.Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agrometeorology,S.R.Ghadekar, 2005, Agromet Publishers, Nagpur.
5. Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.
6. Atmosphere and Ocean, John G.Harvey, 1995, The Artemis Press.

Discipline Specific Elective

DSE-1A: ELEMENTS OF MODERN PHYSICS
(Credits: Theory - 04, Practical - 02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson – Germer experiment.
(8Lectures)

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. **(4Lectures)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(4Lectures)**

Two slit interference experiment with photons, atoms and particles;linear super position principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non- relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.
(**11Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. **(12Lectures)**

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, NZ graph, semi-empirical mass formula and binding energy. **(6Lectures)**

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life & half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. **(11Lectures)**

Fission and fusion-mass deficit, relativity and generation of energy; Fission-nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium-235; Fusion and thermonuclear reactions. **(4Lectures)**

Reference Books:
1. Concepts of Modern Physics,Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, John R. Taylor, Chris D. Zafiratos, Michael A. Dubson, 2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 2008, Tata McGraw-HillCo.
5. Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning
6. Modern Physics, G.Kaur and G.R.Pickrell, 2014, McGrawHill

DSE-1A: ELEMENTS OF MODERN PHYSICS
Practical:
1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. To determine the excitation potential of mercury/argon by Franck-Hertz experiment.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
7. To determine the value of e/m by magnetic focusing.
8. To determine the band gap by measuring the resistance of a thermistor at different temperature.

Reference Books:

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11thEdition, 2011, KitabMahal, NewDelhi.

OR,

DSE- 1A: NUCLEAR & PARTICLE PHYSICS   **(Credits: 06)**
F.M. = 75 (Theory - 60, Internal Assessment – 15)
Internal Assessment [Class Attendance – 05, Class Test/ Assignment/ Seminar – 10]

Theory: **75 Lectures**

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter energy), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10Lectures)**
Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of various terms, condition of nuclear stability. Two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shellmodel, concept of meanfield, residual interaction, concept of nuclearforce. **(12 Lectures)**
Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy.(b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(10 Lectures)**
Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reactionrate, reaction crosssection, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8Lectures)**
Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation, Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.
(8Lectures)

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si &Ge) for charge particle and photon detection (concept of charge carrier and mobility).   **(8 Lectures**)

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.   **(5Lectures)**

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

(14Lectures)

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 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. Theoretical Nuclear Physics, J.M.Blatt & V.F.Weisskopf (Dover Pub. Inc., 1991)

Skill Enhancement Course

SEC-3: COMPUTATIONAL PHYSICS   (Credits: 02)

F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Theory (Class Test/ Assignment/ Seminar)] – 10

Theory: **30 Lectures**
The aim of this course is not just to teach computer programming and numerical analysis but to emphasiz eits role in solving problems in Physics.
- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *Course will consist of hands on training on the Problem solving on Computers.*

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor.

Algorithms and Flowcharts:
Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin (x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.   **(4Lectures)**

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN:CharacterSet, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program,

Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. **(5Lectures)**

Control Statements: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, openafile, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN

2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to writes our ces codes in FORTRAN.

3. To printout all natural even/odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.

5. Calculating Euler number using exp(x) series evaluate datx=1   **(6Lectures)**

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages.

Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors   **(6Lectures)**

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot.importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.

2. To evaluate sum of finite series and the area under a curve.

3. To find the product of two matrices

4. To find a set of prime numbers and Fibonacci series.

5. To write program to open a file and generate data for plotting using Gnuplot.

6. Plotting trajectory of a projectile projected horizontally.

7. Plotting trajectory of a projectile projected making an angle with the horizontal.

8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.

9. To find the roots of a quadratic equation.

10. Motion of a projectile using simulation and plot the output for visualization.

11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.

12. Motion of particle in a central force field and plot the output for visualization.   **(9 Lectures)**

Reference Books:
1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran77, V.Rajaraman (Publisher:PHI).

3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnu plot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986 Mc-GrawHill Book Co.
6. Computational Physics: An Introduction, R.C.Verma, etal. New Age International Publishers, New Delhi (1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn ., 2007, Wiley India Edition.

Semester-VI

DSE- 1B: QUANTUM MECHANICS (Credits: Theory-04, Practical -02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretationof Wave Function Probability and probability current densities in three dimensions;

Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigen functions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.   **(6 Lectures)**

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to the spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle.
                                                                                                         (10 Lectures)

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method.   **(12 Lectures)**

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbersl and m; s, p, d,.. shells (idea only)   **(10Lectures)**

Atoms in Electric and 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.   **(8Lectures)**

Atoms in External Magnetic Fields:- Normal and Anomalous Zeeman Effect.   **(4Lectures)**

Many electron atoms:- Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. 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.   **(10 Lectures)**

Reference Books:

1. A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2ndEd., 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 McGrawHill.
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 for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
7. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
8. Introduction to Quantum Mechanics, David J. Griffith, 2ndEd. 2005, Pearson Education
9. Quantum Mechanics,Walter Greiner,4th Edn., 2001, Springer

DSE- 1B: QUANTUM MECHANICS
   Practical:
   Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited

state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = 2m/\hbar^2 \,[V(r) - E],$$

where $V(r) = -\frac{e^2}{r}$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is $\approx$ -13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = 2m/\hbar^2 \,[V(r) - E],$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = -\frac{e^2}{r}e^{-\frac{r}{a}},$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 (eVÅ)$^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = 2m/\hbar^2 \,[V(r) - E],$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}. In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2 y}{dr^2} = A(r)u(r), A(r) = 2\mu/\hbar^2 \ [V(r) - E],$$

where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), r' = \frac{r - r_0}{r_0},$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: m = 940×10^6 eV/C^2, D = 0.755501 eV, α = 1.44, r_0= 0.131349 Å

Laboratory based experiments:
1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field.
3. To study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Reference Books:
1. Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publications.
2. Numerical Recipes in C: The Art of Scientific Computing, W.H.Press et al., 3rd Edn., 2007, Cambridge University Press.
3. Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn. , 2007, Wiley India Edition.
4. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.VandeWouwer, P.Saucez, C.V. Fernández. 2014 Springer ISBN: 978-3319067896
6. Scilab by example: M.Affouf 2012 ISBN: 978-1479203444
7. Scilab (A Free Software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand and Company, New Delhi ISBN: 978-8121939706
8. Scilab Image Processing: Lambert M.Surhone. 2010 Betascript Publishing ISBN: 978-6133459274A
9. Quantum Mechanics, Leonard I.Schiff, 3rd Edn. 2010,Tata McGrawHill.
10. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

OR,

DSE-1B: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION
(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Seminar) – 05, Practical (Sessional Viva-voce) - 05]

Theory: **60 Lectures**
UNIT-1:
Digital Circuits:
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary andBinary to Decimal Conversion, AND, Or and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.   **(4 Lectures)**
De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products.Minterms and Maxterms.Conversion of a Truth Table into an Equivalent Logic Circuitby (1) Sum of Products Method and (2) Karnaugh Map.   **(5 Lectures)**

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

UNIT-2:
Semiconductor Devices and Amplifiers:
Semiconductor Diodes: p and n type semiconductors.Barrier Formationin PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode.PN junction and its characteristics. Static and Dynamic Resistance. Principleand structure of (1) LEDs (2) Photodiode (3) Solar Cell. **(5Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff, and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Class A, B, and C Amplifiers.

(12Lectures)

UNIT-3:
Operational Amplifiers (Black Box approach):
Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop & Closed-loop Gain.CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and Non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero Crossing Detector. **(13Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator **(5Lectures)**

UNIT-4:
Instrumentations:
Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(3Lectures)**

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation **(6Lectures)**

Timer IC: IC 555 Pin diagram and its application as Astable & Monostable Multivibrator **(3Lectures)**

Reference Books:
1.Integrated Electronics, J.Millman and C.C.Halkias,1991,Tata Mc-GrawHill.
2.Electronic devices and circuits, S. Salivahanan and N. Suresh Kumar, 2012, Tata Mc-GrawHill.
3.Microelectronic Circuits, M.H.Rashid, 2ndEdn., 2011, Cengage Learning.
4.Modern Electronic Instrumentation & Measurement Tech., Helfrick & Cooper,1990, PHI Learning
5.Digital Principles & Applications, A.P. Malvino, D.P. Leach & Saha, 7th Ed.,2011, Tata McGrawHill
6.Microelectronic circuits, A.S.Sedra, K.C.Smith, A.N.Chandorkar, 2014, 6th Edn., Oxford University Press.
7.Fundamentals of Digital Circuits, A.Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt.Ltd.
8.OP-AMP and Linear Digital Circuits, R.A.Gayakwad, 2000, PHI Learning Pvt. Ltd.

DSE- 1B: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION
Practical:
1.   To measure (a)Voltage, and (b) Frequency of a periodic wave form using a CRO
2.   To verify and design AND, OR, NOT and XOR gates using NAND gates.
3.   To minimize a given logic circuit.
4.   Half adder, Full adder and 4-bit Binary Adder.
5.   Adder-Subtractor using Full Adder I.C.
6.   To study I-V characteristics of PN diode and Zener diode.
7.   To study the characteristics of a Transistor in CE configuration.
8.   To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.

9.   To design an inverting amplifier of given gain using an Op-amp 741 and study its frequency response.
10.   To design an non-inverting amplifier of given gain an Op-amp 741 and study its frequency response.

Reference Books:
1.   Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
2.   Electronics: Fundamentals and Applications, J.D.Ryder, 2004, Prentice Hall.
3.   OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
4.   Electronic Principle, Albert Malvino, 2008, Tata Mc-GrawHill.

Skill Enhancement Course

SEC- 4: ELECTRICAL CIRCUITS AND NETWORK SKILLS   (Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Theory (Class Test/ Assignment/ Seminar)] – 10

Theory: **30 Lectures**
The aim of this course is to enable the students to design and troubleshoots the electrical circuits, networks and appliances through hands-on mode

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations.AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.   **(3Lectures)**
Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements.Single-phaseandthree-phasealternatingcurrentsources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.
                                                                                               (4Lectures)
Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.   **(4Lectures)**
Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.   **(3Lectures)**
Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.   **(4 Lectures)**
Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or A C   sources   **(3Lectures)**
Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)   **(4Lectures)**
Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit.Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.   **(5Lectures)**

Reference Books:
1.   A text book in Electrical Technology-B L Theraja-S Chand & Co.
2.   A text book of Electrical Technology-A K Theraja
3.   Performance and design of AC machines-M G Say ELBS Edn.