## Core 17: IPH6CR01 – Mathematical Physics - I
## Credit: 2 (72 Hours)

**Module I Vector analysis (9 hrs)**

Review of vector algebra, differential calculus- Gradient, divergence and curl of vector Functions, and the physical significance, Integral calculus-Line, Surface and Volume integrals,
Fundamental theorems- Gauss Divergence Theorem, Stoke's Theorem, Green's Theorem, Application of vectors-potential formulations- Gravitational Potential, Poisson's Equation. Gauss's Law of Gravitation.

**Curvilinear co-ordinates (9 hrs)**

Concepts of rectangular Cartesian Co-ordinate system, Orthogonal Curvilinear co-ordinates, Cylindrical Coordinates, Spherical Polar Co-ordinates. Transformation of co-ordinates, Unit Vectors in curvilinear systems, Arc Length and Volume Elements, Gradient, Divergence and Curl in orthogonal curvilinear co-ordinates.

**Linear vector space ( 9 hours)**

Definition of linear vector space, inner product of vectors, basis sets, Gram Schmidt orthonormalization, Expansion of an arbitrary vector, Schwarz inequality.

**Module 2 Matrices and Tensors (18 hr)**

Direct Sum and Direct Product of Matrices, Diagonal matrices, Matrices inversion (Gauss Jordan Inversion Methods), Orthogonal, unitary and Hermitian Matrices Cayley Hamilton Theorem, Similarity transformation, Orthogonal & Unitary Transformations, Eigen values & Eigen Vectors, Diagonalization using normalized Eigen vectors, Pauli spin matrices, Dirac matrices, Normal matrices.
Definition of Tensors, Basic Properties of Tensors, Covariant, Contra variant & Mixed Tensors, Kronecker delta, Levi-Civita Tensor, Metric Tensor and its properties

**Module 3 Special functions and differential equations**

**Beta and Gamma functions (9 hours)**

Gamma Function, Beta Function, Symmetry Property of Functions, Evaluation of Beta functions, Transformation of Beta Functions, Evaluation of Gamma Functions, Transformation of Gamma Functions, Relation between Beta and Gamma Functions.

**Differential Equations (18 Hours)**

Linear differential equation of first order and its solutions, solution of second order differential equations with constant coefficients, Power series solution, Bessel's Differential Equation, Legendre Differential Equation, Associated Legendre Differential Equations, Hermite Differential Equations,
Laguerre Differential Equations (Generating function, recurrence relation, orthogonality condition, Rodrigues formula for all functions)

**Text Books:**

1. Mathematical methods for Physicists, G.B. Arfken & H.J. Weber 5th edition, Academic Press.
2. Mathematical Physics , V.Balakrishnan, Ane Books Pvt Limited

3. Introduction to Mathematical Physics – Charles Harper, PHI
4. Vector Analysis & Tensor Analysis – Schaum's Outline Series, M.R.Speigel, Mc Graw hill
5. Mathematical methods for physics and engineering, K F Riley, M P Hobson, S J Bence, Cambridge university press.

**Reference Books:**

1. Advanced Engineering Mathematics E.Kreyszig 7thedition John Wiley
2. Mathematical Physics, B.S.Rajput,Y.Prakash 9th edition PragatiPrakashan
3. Mathematical Physics, B.D.Gupta ,Vikas Publishing House
4. Matrices and tensors in Physics,A.W.Joshi
5. Mathematical Physics , P.K.Chatopadhyay ,New Age International Publishers
6. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons

## Core 18: IPH6CR02 – Numerical Analysis
## Credit: 2 (54 Hours)

**Module I Curve Fitting and Interpolation (16 Hrs)**

The least squares method for fitting - a straight line, a parabola, an exponential curve. Interpolation - Introduction to finite difference operators, Newton's forward and backward difference interpolation formula, Cubic spline interpolation.

**Module II Numerical Differentiation and Integration(8 Hrs)**

Numerical differentiation, errors in numerical differentiation, Integration of a function with Trapezoidal Rule, Integration of a function with Simpson's

**Module III Numerical Solution of Ordinary Differential Equations (20Hrs**)

Euler method, modified Euler method, Runge - Kutta methods-adaptive step size R-K method, Higher order equations. Numerical Solution of System of Equations Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss-Jordan method to find inverse of a matrix, Power method, Jacobi's method to solve eigenvalue problems.

**Module IV Numerical solutions of partial differential equations (10 Hrs)**

Elementary ideas and basic concepts in finite difference method, Schmidt Method, Crank - Nicholson method, Weighted average implicit method, Monte Carlo evaluation of integrals, Buffon's needle problem, requirement for random number generation.

**Text Books:**

1. Numerical Methods for Scientists and Engineers , K SankaraRao,PHI Pvt. Ltd.
2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

3. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

**Reference Books:**

1. An Introduction to Computational Physics, Tao Pang, Cambridge University Press
2. Numerical methods for scientific and Engineering computation M.K Jain,S.R.KIyengar, R.K. Jain, New Age International Publishers
3. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
4. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
5. Numerical Mathematical Analysis, J.B. Scarborough, 4PthP Edn, 1958
6. Explorations in Monte Carlo Methods Ronald W Shonkwiler and Franklin Mendivil, Springer

## Core 19: IPH6CR03 – Statistical Mechanics - II
## Credit: 2 (54 Hours)

**UNIT I Thermodynamics and Statistical theory (18 hours)**

Definition of quantum state of the system- A simple model of spins on lattice sites - Equations of states - spin system - vacancies in a crystal- The second law of thermodynamics

Canonical ensemble : A system in contact with a heat bath - The partition function - Entropy in a canonical ensemble - Bridge to thermodynamics through Z - Condition for thermal equilibrium - Thermodynamics quantities from ln(Z) -two level system - Single particle in 1D box, 3D box - Expression for heat and work - rotational energy levels and vibrational energy levels for diatomic molecules - factorizing the partition function - equipartition theorem

**Text Book**

Introductory Statistical Mechanics - Roger Bowley and Mariana Sanchez, Second Edition , Clarendon Press-Oxford 1999 Chapter 4 & Chapter 5

**UNIT II (14 hours)**

**Identical particles** - symmetric and antisymmetric wave functions - Bosons - Fermions - partition function for bosons and fermions - spin - identical particle localized on lattice sites - identical particles in a molecule

**Planks Distribution** - Black body radiation -The Rayleigh Jeans theory - Plank distribution -waves as particles - derivation of Plank's distribution - the free energy - Debye model of vibrations in a solid

**Text Book**

**I**ntroductory Statistical Mechanics - Roger Bowley and Mariana Sanchez, Second Edition , Clarendon Press-Oxford 1999 Chapter 6 & Chapter 8

**UNIT III (22 hours)**

**System with variable number of particles**

System with variable number of particles - condition for chemical equilibrium - approach to chemical equilibrium - chemical potential - methods for calculating and measuring chemical potential - reactions - external chemical potential- grand canonical potential - absorption of atoms on surface sites - the grand potential

**Fermi and Bose Particles**

Statistical mechanics of identical particles - Fermi particles-Bose particles- thermodynamic properties of a Fermi gas - High temperature region - at absolute zero - at low temperature - Fermi systems : Electrons in metals- non interacting Bose gas

**Phase Transition**

Phases - thermodynamic potential - approximation - first order phase transition - Clapeyron equation - continuous phase transition - Ising model

**Text Book**

Introductory Statistical Mechanics - Roger Bowley and Mariana Sanchez, Second Edition , Clarendon Press-Oxford 1999 Chapter 9, Chapter 10 and Chapter 11

**References:**


1. Introductory Statistical Mechanics –Roger Bowley
2. Statistical Mechanics - R K Pathria
3. Statistical Mechanics - K Huang
4. Statistical Mechanics - Donal A McQuarrie
5. Statistical Mechanics – Donald A. Mc Quarrie
6. Statistical Mechanics and Properties of Matter – E S R Gopal
7. Fundamentals of Statistical and Thermal Physics - Federick R


## Core 20: IPH6CR04 –Particle Physics
## Credit: 2 (54 Hours)

**Module I- Particle Accelerators (20 Hours)**

Van de Graaff generators, the linear accelerators, cyclotron, the synchrocyclotron, the betatron, the synchrotrons, the proton synchrotron- bevatron- cosmotron, neutron diffusion, solution to diffusion equation, diffusion of fast neutron and fermi age equation, continuum theory of nuclear reaction, optical model theory of nuclear reactions, photo- nuclear reactions.

Interaction of charged particles with matter, rate of loss of energy of a charged particle traversing a material medium, bremsstrahlung, neutron decay, stability of proton, resonance particles, detection of neutrino.

Discover of cosmic rays, latitude effects, azimuth effects, altitude effects, longitude effects, primary and secondary cosmic rays, cosmic ray showers, van allen belt, the big bang theory, thermal history of universe, hubble's law, the future of universe.

**Module II- Elementary particles (18 hrs)**

Yukawa's hypothesis; properties of pi mesons- electric charge, isospin, mass, spin and parity., Decay modes and production of pi-mesons, Types of interactions between elementary particles, Hadrons and leptons, Symmetries and conservation laws, C P and CPT invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions, Quark model, confined quarks, coloured quarks and gluons, experimental evidences for quark model, quark-gluon interaction, quark dynamics, Grand unified theories, standard model of particle physics

**Module-III Nuclear Astrophysics and Practical Applications of Nuclear Physics (16 Hrs.)**

Particle and nuclear interactions in the early universe, primordial nucleosynthesis, Stellar nucleosynthesis (for both A<60 and A>60), Higg's boson and the LHC experiments; detection of gravitational waves and LIGO (qualitative ideas only), Rutherford Backscattering spectroscopy and applications, Computerized Axial Tomography (CAT), Positron Emission Tomography (PET)

**References**


1. Concepts of Modern Physics, Arthur Beiser, 6th Edition, Tata McGraw-Hill publishing company
2. Modern Physics, R Murugeshan and K. Sivaprasath, 15th Edition (Revised) (2010), S.Chand.
3. Atomic and Nuclear Physics, S N Ghoshal, S.Chand.
4. Nuclear and Particle Physics S L Kakani and SubhraKakani -Viva Books 2008.
5. Elements of Nuclear Physics, M L Pandya and R P S Yadav, KedarNath Ram Nath
6. Modern Physics, KennthKrane, 2nd Edition, Wiley India (Pvt) Ltd.
7. Modern Physics , G. Aruldhas and P. Rajagopal, Prentice-Hall India

## Core Practical: IPH6CP05 – Physics Practical - X

## Credit: 2 (36 Hours)

(The student has to complete at least 10 experiments)

*Note:*

- Develop algorithm / Flowchart for all experiments
- Codes can be developed in any package / programming language. Candidate should be trained to explain parts of the codes used.
- Plotting can be done in any plotting package and can be separate from the programming package / environment.
- Training may be given to use methods discussed below to solve real physics problems.

1. Plotting Boltzmann distribution, Maxwell velocity distribution.
2. Concepts of Partition function, Entropy and Free energy.
3. Energy levels of harmonic oscillator.
4. Plotting Magnetization and Susceptibility of Paramagnet
5. Grand Canonical ensemble-1D Ising model
6. Ideal gas in canonical ensemble - mean energy and mean pressure.
7. Find the root of the given non-linear equations by the bisection method
8. Find the root of the given non-linear equations by the Newton-Raphson method
9. Newton's forward interpolation / backward interpolation.
10. Numerical integration by the trapezoidal rule.
11. Numerical integration by the Simpson rule (both 1/3 and 3/8 rule).
12. Fit a straight line using method of least square to a set of given data without using any built-in function of curve fitting. Compare your result with any built in curve fitting technique.
13. Numerical solution of ordinary first-order differential equations using the Euler methods **or** the fourth order Runge-Kutta method.
14. Using technique of Monte Carlo method obtain the value of $\pi$ (pie) correct to two decimal places.
15. Using Monte Carlo technique calculate the value of the given integral. Compare the result with result obtained by analytical method.

**Reference books:**


1. Computational Physics: An Introduction, R.C. Verma, P.K. Ahluwalia & K.C. Sharma, New Age India, Pvt. Ltd ,2014.
2. An Introduction To Computational Physics, 2nd Edn,Tao Pang Cambridge University Press, 2010.
3. Numerical Recipes: The Art of Scientific Computing 3rd Edn, William H. Press Cambridge University Press, 2007.

## Core Practical: IPH6CP06 – Physics Practical - XI

## Credit: 2 (36 Hours)

(The student has to complete at least 10 experiments)

1. Determination of lattice parameters using XRD for cubic systems
2. Compare the optical absorption spectrum of a direct and an indirect band gap semiconductor specimen using simulation technique and estimate the band gap in each case.
3. Electrical conductivity of electrolytes using conductivity meter and its pH measurements
4. Study the dielectric measurements of a material as a function of frequency using LCR Q-Meter.
5. Add two vectors using Python or any programming language.
6. Find sum, mean and product of vector using Python or any programming language
7. Print the Fibonacci sequence by giving necessary inputs. Use Python or any other programming language.
8. Find the factors of a number using Python or any other programming language.
9. Calculator Applications using Python or any other programming language
10. Reading and writing different types of datasets using Python or any programming language.
11. Compute the inverse of the resultant matrix using Python or any programming language
12. Compute the determinant matrix using Python or any programming language
13. Compute the Eigenvalues/eigenvector. x1 + x2 = 2, −x1 + x2 = 4 using Python or any programming language
14. Solve the system of linear equations 5x + y = 15, 10x + 3y = 9 using Python or any programming language
15. Write a program to access the element at 3rd column and 2nd row, only the 3rd row and only the 4th column of a given matrix.

**References:**


1. Kenneth H. Rosen, “Discrete Mathematics And Its Applications”, 7th Ed, McGraw Hill, 2012.
2. Erwin Kreyszig, “Advanced Engineering Mathematics”, Wiley India, 9th Edition 2011.
3. 4. Thin film phenomena, K.L Chopra, McGraw Hill, New York
4. 5. Crystallography for Solid State Physics: Verma & Shrivastava.
5. 6. A textbook of nano science and nanotechnology, T. Pradeep, Tata McGraw-Hill

## Core Practical: IPH6CP07 – Physics Practical - XII

## Credit: 2 (36 Hours)

(The student has to complete at least 10 experiments)

1. Magnetic susceptibility - Guoys method
2. Y, n, σ Cornu's method, (a) Elliptical fringes
3. Y, n, σ Cornu's method, (b) Hyperbolic fringes
4. Hydrogen spectrum – Rydberg constant
5. Oscillating disc – viscosity of liquid
6. Mutual inductance – Carey Foster's bridge
7. Self and mutual inductance – Anderson's bridge
8. Electrical and thermal conductivity of copper and determination of Lorentz Number.
9. Silicon diode as temperature sensor.
10. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility.
11. Diffraction of light by cross wire and wire mesh using laser.
12. Diffraction of light by double slit and grating using laser.
13. Cauchy's constant of liquid and liquid mixture using holoprism and spectrometer.
14. Surface tension of a liquid using Jaegger's method.
15. Identification of Fraunhoffer lines in solar spectrum.

**References**


1. Advanced practical physics for students, B.L Worsnop and H.T Flint, University of California.
2. A course on experiment with He-Ne Laser, R.SSirohi, John Wiley & Sons (Asia) Pvt.ltd.
3. Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan ,K.R Priolkar, Indian Academy of Sciences.
4. Advanced Practical Physics, S.P singh, PragatiPrakasan.
5. Practical Physics, Gupta, Kumar, PragatiPrakasan.
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd:

## IPH6PR08 Minor Project Credits - 2

The student has to complete a **Minor Project** in the 6th semester and has to submit it for evaluation. Project work shall be completed in accordance with the guidelines given by the department. Minor Project may be carried out under the supervision of a teacher of the concerned department. The project work may be done individually or as a group of two students.

Evaluation of the Minor Project will be done in the **sixth** semester. There shall be an internal assessment and external assessment for the Project Work. The components for internal evaluation are shown in the table below.

The external evaluation of the Project Works shall be conducted by two examiners; one external examiner and one internal examiner. The Project Work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the viva-voce of the project.

The components and its weightages for Minor Project evaluation (for both internal & external) are given below.

### a) For Minor Project – Continuous Evaluation (CE)/Internal

| No. | Components | Weightage |
|---|---|---|
| I | Project Involvement & Data collection. | 2 |
| II | Project Analysis & Presentation | 2 |
| III | Project Viva | 1 |
| | **Total** | **5** |

(The components and its weightage of the Minor Project - Internal may be modified by the concerned BOS without changing the total weightage 5)

### b) For Minor Project – End Semester Evaluation (ESE)/External

| No. | Components | Weightage |
|---|---|---|
| I | Relevance of the topic & Analysis | 6 |
| II | Project content, Presentation & Report. | 6 |
| III | Project Viva | 3 |
| | **Total** | **15** |

(The components and its weightage of the Minor Project - External may be modified by the concerned BOS without changing the total weightage 15)

# A. ELECTIVE COURSES

## SEMESTER VI
## ELECTIVE I - BUNCH A
## IPH6ELA1 – Physics of Nano Materials
## Credit: 4 (72 Hours)

**Module I: Introduction to Nanoscience (18 hrs)**

Definition of nanoscience, Nano the Beginning Nano and energetics, Nano and implication, General issues of concern of Synthesis of Nanomaterial, Synthesis methods: the common issue of concern Variety in nanomaterials

**Module II: Properties of Individual Nanoparticles (18 hrs)**

Metal nano clusters-Magic numbers, theoretical modelling of nanoparticles, geometric structure, electronic structure, bulk to nanotransition, Semiconductor nanoparticles-optical properties, photofragmentation. Method of synthesis - rf plasma, chemical methods, thermolysis, pulsed laser method.

**Module III: Carbon Nano structures (18 hrs)**

Carbon molecules-nature of carbon bond, carbon clusters-discovery of C60,structure of C60, superconductivity in C60, larger and smaller Fullerenes, carbon nanotubes-fabrication, structure, electrical, mechanical and vibrational properties. Applications of carbon nanotubes.

**Module IV: Quantum wells, wires and dots (18 hrs)**

Introduction, preparation of quantum nanostructures, Size and dimensionality effects- size effects, conduction electrons and dimensionality- Fermi gas and density of states - potential well -partial confinement-properties dependent on density of states-excitons-single electron tunneling, Applications- Infrared detectors-Quantum dot lasers - Superconductivity.

**Text book**


1. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
2. A textbook of nanoscience and nanotechnology, T. Pradeep, Tata McGraw-Hill Education.
3. Nanostructures and Nanomaterials - Synthesis, Properties and Applications – Guozhong Cao, Imperial college press.


**Reference Books:**


1. Introduction to nanoscience and nanotechnology. Chris Binns, John Wiley & Sons.
2. Basic Principles of Nanotechnology, By Wesley C. Sanders, CRC Press.
3. Textbook of nanoscience and nanotechnology. B. S. Murty, Springer.
4. Handbook of microscopy for nanotechnology. Nan Yao, Lin Wang Zhong, Kluwer academic publishers.
5. Nano: the essentials.T. Pradeep, Tata McGraw-Hill Education.
6. Fundamentals of nanotechnology, G. L Hornyak, H. F. Tibbals, J. Dutta, & , J. J Moore. CRC press.

7. Introduction to Nanoscience, Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, Anil Rao, CRC Press.
8. Handbook of Nano Physics Nanoparticles and Quantum Dots Klaus D Sattler CRC Press Taylor and Francis Group

## IPH6ELA2 – Nonlinear Dynamics
## Credit: 4 (72 Hours)

**Module I: Dynamics of one and two dimensional systems (27 hours)**

Linear and Nonlinear Systems, Determinism, Unpredictability and Divergence of Trajectories, State Space, Systems Described by First-Order Differential Equations, Dissipative and Conservative systems, Attractors in dissipative Systems, One-Dimensional State Space, Linear Stability Analysis-Taylor Series Linearization near Fixed Points, Trajectories in a One-Dimensional State Space, Two Dimensional State Space: The General Case, Dynamics and Complex Characteristic Values, Dissipation and the Divergence Theorem, Limit Cycles, Poincare Sections and the Stability of Limit Cycles, Bifurcation Theory, Lyapunov exponent of a one dimensional map (18 hours)

Logistic map and universality of Chaos (9 Hours): Discrete dynamical systems Logistic map, Period doubling bifurcations, Feigenbaum numbers, Convergence ratio for real systems, Feigenbaum Size scaling, Self-Similarity, Other Universal features, Fractals-Cantor Set, Koch Curve.

**Module II: Dynamics of three dimensional systems (18 hours)**

Overview, Heuristics, Routes to Chaos, Three-Dimensional Dynamical Systems, Fixed Points in Three Dimensions, Limit Cycles and Poincare Sections, Quasi -Periodic Behavior, The Routes to Chaos – Period - Doubling, Quasi- Periodicity, Intermittency and Crises, Chaotic Transients and Homoclinic Orbits, Homoclinic Tangles and Horseshoes, Lyapunov Exponents and Chaos, Model of Convecting Fluids- Lorenz Model, Duffing Double well oscillator, Van der Pol Oscillator.

**Module III: Hamiltonian systems (18 Hours)**

Introduction, Liouville's theorem and phase space distribution, Constants of the Motion and Integrable Hamiltonians, The simple Harmonic oscillator, The Pendulum, Systems with N degrees of freedom, Nonintegrable Systems, KAM Theorem and Period Doubling, Poicare -

Birkoff Theorem, Henon-Heiles system, Chirikov Standard Map, Arnold Cat Map, Dissipative Standard Map.

**Module IV: Measures of Chaos (9 Hours)**

Introduction, Time-Series of Dynamical Variables, Lyapunov Exponents, Universal Scaling of the Lyapunov Exponent, Invariant Measure, Kolmogorov-Sinai Entropy, Correlation Dimension, Fractal Dimension(s).

**Text Books:**

1. Chaos and Nonlinear Dynamics, 2nd Edition, R. C. Hilborn, Oxford
2. Deterministic Chaos, 1996 edition, N. Kumar, Universities Press

**References:**

1. Nonlinear Dynamics and Chaos with applications to Physics, Biology, Chemistry and Engineering, 1994 Edition, Steven H. Strogatz, Perseus Book Publishing.
2. Nonlinear dynamics: integrability, chaos, and patterns, 2003 edition, M. Lakshmanan & S. Rajasekar, Springer Verlag
3. Chaotic Dynamics: An Introduction, 1993, G. L. Baker, and J. P. Gollub, CUP
4. Deterministic Chaos, 1995, H.G. Schuster, Wiley, N.Y.
5. Chaos in Dynamical System, 2nd Edition, E. Ott, Cambridge University Press.
6. Encounters with Chaos, 1992, D. Gullick, MGH
7. Nonlinear Dynamics and Chaos, 2nd Edition, J.M.T. Thomson & I. Stewart, John Wiley & Sons.

# B. AUDIT COURSES

Any of these courses shall be selected as Audit course for the corresponding semester as per the scheme. One course cannot be selected for more than one semester.
**No credits shall be awarded for Audit courses.**

## Audit Course 1: IPHAUT1 – Virtual Lab
## Credit: Nil (18 Hours)

Familiarising virtual lab platform

Lab activities

**Session 1**

1. Compound Pendulum
2. Rigidity modulus of the suspension of the wire of a torsion pendulum
3. Tangent Galvanometer
4. Deflection Magnetometer
5. Newton's Rings – Wavelength

**Session II**

1. Zener Diode as Voltage Regulator
2. Newton Law of Cooling
3. Numerical Aperture of Optical Fibre
4. Moment of Inertia of Fly Wheel
5. Parallel LCR circuit

**Reference**

1. https://vlab.amrita.edu
2. https://www.olabs.edu.in

## Audit Course 2: IPHAUT2 – Computer Aided Design
## Credit: Nil (18 Hours)

**Unit I**

Engineering applications, Statement of optimization problem, Classification of optimization problems, Optimization techniques. Single variable optimization, Multivariable optimization with no constrains, with equality constraints - Lagrange multiplier - method, constrained variation method - and with inequality constraints Kuhn Tucker conditions.

**Unit II**

Linear Programming: Standard form of Linear programming problem, simplex method, revised simplex Method.

**Unit III**

Non-Linear Programming: One dimensional minimization methods, Elimination and Interpolation methods, unconstrained Optimization Techniques, Direct Search methods, Descent Methods, Constrained Optimization Techniques, Direct methods. Indirect methods.

**Textbooks**

1. Rao.S.S - Optimization Theory and Applications, Wiley Eastern Limited, 1978.
2. Fox.R.L. - Optimization Methods for Engineering Design, Addison Wesley,
3. 1971 Srinath. L.S., Advanced Mechanics of Solids, Tata M Publishing Co ltd., New Delhi

## Audit Course 3: IPHAUT3 – Energy Audit Course
## Credit: Nil (36 Hours)

**Unit 1**

Introduction to energy management and energy audit, Sources of Energy, Need of energy conservation, Power generation, transmission and distribution.

**Unit 2**

Energy and utilities, Input and output power, Losses, Star rating in equipment, energy saving methods in industries, high efficiency drives, VFD, energy saving in compressed air system, waste heat recovery systems, Green mobility, Types of equipment in a utility, Refrigerator, A/C, Washing machine, Mixie, Specification, star rating, lightings, Consumption of energy, Energy calculation from different loads, Tariff structure in Kerala

**Unit 3**

Solar PV systems, invertor, Battery, maintenance of battery ,maintenance of solar PV system, Energy Management, Key elements for successful energy management, Effective energy management, Positive and negative forces to reduce energy consumption.

**Unit 4:**

Energy audit, Types of energy audit, Report on energy audit, Production factor, Instruments and meters for energy audit, BEE Regulations 2008 related with energy audit. Familiarisation of data collection form and report preparation methods

**Textbooks**

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul o' Callaghan, Mc–Graw Hill Book company–1st edition, 1998.
3. Energy management hand book by W.C.Turner, John wiley and sons.

## Audit Course 4: IPHAUT4 – Python Programming
## Credit: Nil (36 Hours)

**Unit I**

This unit will introduce the structure of a Python program and how it is executed. Concepts of variables and objects, formatting of text, string, numbers, and arrays are considered. Arithmetic operations, parenthesis and rounding of errors shall be discussed. Method of plotting in Python shall be introduced.

**Unit II**

Basic control constructs are introduced in this unit. Syntax of 'if', 'else', and 'elif' are introduced. The method using functions is explained. The 'for' and 'while' loops are introduced. The use of list and tuples and the method of reading from and writing to files are also considered.

**Unit III**

Lab Exercises 1. Understand the basics of Python: 1.1. Data types, 1.2.Loops, 1.3.Conditional Statements, 1.4.Functions 1.5.Modules.

**Text-books**


1. S. Linge and H.P. Langtangen, Programming for Computations – Python, Springer Open (2019) (Open access book).
2. Amit Saha, Doing Math with Python, No Starch Press (2015). Chapters 2-5, and 7 (Relevant topics only).


## Audit Course 5: IPHAUT5 – Course on LaTex
## Credit: Nil (18 Hours)

**Unit I**

Preparing an Input File--Sentences and Paragraphs- Quotation Marks- Dashes - Space After a Period - Special Symbols - Simple Text-Generating Commands- Emphasizing Text - Preventing Line Breaks -Footnotes - Formulas -The Document - The Document Class –The Title " Page " -Sectioning - Displayed Material- Quotations - Lists - Displayed Formulas- Declarations - Running TEX. Carrying On - Changing the Type Style- - Symbols from Other Languages-- Accents - -Symbols- - Mathematical Formulas -Some Common Structures- Subscripts and Superscripts- Fractions - Roots - Mathematical Symbols- Greek Letters- Calligraphic Letters - Mathematical Symbols -Log-like Functions

**Unit II**

Arrays- The array Environment - Vertical Alignment – Delimiters - Over-and Underlining- Accents - Type Style -Math Style- Figures and Other Floating Bodies - Figures and Tables - Marginal Notes - Lining It Up in Columns Moving Information Around - The Table of Contents - Cross-References- Bibliography and Citation - Using BIBTEX- Making an Index - Producing an Index -Other Document Classes - Books - Slides – Notes -Other Text - Letters .

**Unit III**

LaTex Activities

1. Preparation of a Document – Article.
2. Preparation of a Document with Inserting The Title Page , Abstract and bibliography.
3. Preparation of a Document with Custom Style and Page Styles.
4. Preparation of a Document with Line and Page Breaking - Numbering -Length, Spaces, and Boxes- Centring and " Flushing"
5. Preparation of a Document with Pictures and Colours.
6. Preparation of a Document with The picture Environment -Picture Objects- Text. '-Boxes - Straight Lines – Arrows-Curves - Grids .
7. Preparation of a Document with The graphics Package.
8. Preparation of a Document - different Class Options, books, conference, report and letter.
9. Preparation of a Latex Slides using Beamer presentation

**References**

1. LaTex “A document preparation system”, Leslie Lamport, second edition, Pearson Education, 2008.
2. LaTeX: A document preparation system, 2nd Edition, Leslie, Lamport, Addison-Wesley, 1994.
3. The LaTeX Companion: 2nd Edition, Fittelbach, M. Goossens. et.al., 2004.

## Audit Course 6: IPHAUT6 – MATLAB Programming
## Credit: Nil (18 Hours)

**Unit I.**

Introduction to Programming-Components of a computer-Working with numbers-Machine code- Software hierarchy- Programming Environment -MATLAB Windows-A First Program-Expressions, Constants- Variables and assignment statement-Arrays.

**Unit II**

Graph Plots-Basic plotting -Built in functions-Generating waveforms-Sound replay, load and save-Procedures and Functions-Arguments and return values-M-files- Formatted console input-output-String handling

**Unit III**

Control Statements -Conditional statements: If, Else, Elseif-Repetition statements: While, For-Manipulating Text-Writing to a text file-Reading from a text file- Randomising and sorting a list-Searching a list.

**Textbooks**

1. MATLAB Programming for Engineers. by Stephen J. Chapman.
2. Understanding MATLAB: A Textbook for Beginners by S.N. Alam S.S. Alam.

## Audit Course 7: IPHAUT7 – Research Paper Writing
## Credit: Nil (18 Hours)

**Unit 1**

Scientific Writing Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports - Illustrations and tables.

**Unit II**

Bibliography, Referencing and foot notes – Oral presentation – Planning – Preparation and practice – Making presentation – Use of visual aids – Importance of Effective Communication. Conventions and strategies of Authentication – Citation Style – sheet Preparing Research papers for journals, Seminars and Conferences.

**Unit III**

Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN. Preparation of Project Proposal - Title, Abstract, Introduction – Rationale, Objectives, Methodology – Time frame and work plan – Budget and Justification.

**Textbooks**

1. Day RA (1992) How to write and publish a scientific paper. Cambridge University press. London.
2. Hempel,C. Philosophy of Natural science Englewood Cliffs, N.J: Prentice Hall, 1966.
3. Burtt, E.A. The Metaphysical Foundations of Modern Science. London, 2003.