MASTER OF SCIENCE IN

PHYSICS

SCHEME AND SYLLABUS
(2023-24 ONWARDS)

DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY KURUKSHETRA
KURUKSHETRA-136119
HARYANA, INDIA

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SCHEME

Semester-I:

S. No.	Course Code	Course Title	L	T	P	Credits
1.	PHPC501	Classical Mechanics	3	0	0	3
2.	PHPC503	Quantum Mechanics	3	0	0	3
3.	PHPC505	Mathematical Physics	3	0	0	3
4.	PHPC507	Electrodynamics	3	0	0	3
5.	PHPC509	Nuclear and Particle Physics	3	0	0	3
6.	PHPC511	Physics Lab	0	0	6	3
7.	PHPC513	Computational Physics Lab	0	0	4	2
8.	SWNC101	Sports/Yoga (Non-Conventional Institute Core)	0	0	**2**	1
			Total Credit			**21**

Semester-II:

S. No.	Course Code	Course Title	L	T	P	Credits
1.	PHPC502	Advanced Quantum Mechanics	3	0	0	3
2.	PHPC504	Solid State Physics	3	0	0	3
3.	PHPC506	Thermodynamics and Statistical Physics	3	0	0	3
4.	PHPC508	Electronics	3	0	0	3
5.	PHPC510	Atomic and Molecular Physics	3	0	0	3
6.	PHPC512	Electronics Lab	0	0	6	3
7.	PHPC514	Analytical Instrumentation Lab	0	0	6	3
8.	SWNC101	Sports/Yoga (Non-Conventional Institute Core)	0	0	**2**	1
			Total Credit			**22**

Course Code PHPC 501	Classical Mechanics	Credits 3-0-0: 3

Course Educational Objectives :

CEO1	To explain the difference between Newtonian mechanics and analytical mechanics.
CEO1	To understand and answer problems on damped and forced oscillatory systems, and simple coupled systems.
CEO1	Understand the physical principle behind the derivation of Lagrange's and Hamilton's equations, and the advantages of these formulations.

UNIT-1 **6 L**

Introduction: Newtonian mechanics: Mechanics of a particle and a system of particles; Constraints and their classification, Examples of constraints, Degrees of freedom, Constraints, Generalized coordinates, Virtual displacement, Virtual work, and generalized forces, Two body Collisions - scattering in laboratory and Centre of mass frames, moment of inertia tensor, Non-inertial frames and pseudo-forces.

UNIT-2 **12 L**

Lagrangian Dynamics: D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and dissipation function, Simple applications of the Lagrangian formulation, Variational principles and Lagrange's equations.

Central Force: Definition and properties of central force, Reduction to the equivalent one-body problem, The equation of motion and first integrals, The equivalent one-dimenmsional problem, and classification of orbits; The Virial theorem, The Kepler problem: Inverse-square law of force, Orbits of artificial satellites.

UNIT-3 **9 L**

Rigid Body Motion: The independent coordinates of a rigid body: Degrees of freedom and kinetic energy; orthogonal transformations, Angular momentum and kinetic energy of motion about a point, The inertia tensor and the moment of inertia, The eigen values of the inertia tensor and the principal axis transformation, Euler equations of motion, Torque free motion of rigid body.

Small Oscillations: Theory of small oscillations, Frequencies of free vibration and normal coordinates Free vibrations of a linear tri-atomic molecule, Forced vibrations and the effect of dissipative forces.

UNIT-4 **9 L**

The Classical Mechanics of the Special Theory of Relativity: Basic postulates of the special theory, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

Hamiltonian Dynamics: Legendre transformations and the Hamilton equations of motion, Cyclic coordinates and conservation theorems, The Hamiltonian formulation of relativistic mechanics, Derivation of Hamilton's equations from a variational principle, The principle of least action, Hamilton's canonical equations, Hamilton's variational principle, Poisson brackets and other canonical invariants, The angular momentum Poisson bracket relations, Phase space and Liouville's theorem, The Hamilton-Jacobi theory, invariance and Noether's theorem.

Reference Books:

1. **Goldstein, H**., Classical Mechanics, Pearson New, 2011.
2. **Rana, N. C. and Joag, P. S**., Classical Mechanics, Tata McGraw Hill, 1991.
3. **Landau, L. D. and Lifshitz, E. M**., Mechanics, Pergamon Press, 1960.
4. **Meirovitch, L.,** Methods of Analytical Dynamics, McGraw Hill, 1999.
5. **SrinivasaRao, K. S**., Classical Mechanics, Universities press, 2003.

Course Outcomes: Students will be able to:

CO1	Relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.
CO2	Solve dynamical problems involving classical particles by using the Lagrangian and Hamiltonian formulation.
CO3	Demonstrate working knowledge of classical mechanics and application to standard problems on central forces.

Course Code PHPC 503	Quantum Mechanics	Credits 3-0-0: 3

Course Educational Objectives :

CEO1	To familiarize the foundation of quantum mechanics.
CEO1	To introduce time evolution of quantum states & operators, and various quantum parameters.
CEO1	To familiarize students to the quantum dynamics and quantum analysis of angular Momentum.

UNIT-1 **9 L**

Fundamental Concepts: Problems with classical physics, Principle of superposition, Postulates of Quantum Mechanics, The corpuscular and wave models of light, Particle nature of radiation: Photoelectric and Compton effect, De Broglie's hypothesis: Wave-particle duality, The Davisson-Germer experiment, Stern- Gerlach experiment, The Franck-Hertz experiment.

UNIT-2 **9 L**

Formalism: Vectors and vector spaces, Hilbert space, Inner products, Matrices, Eigenvectors and eigenvalues, Hermitian transformations, Representations of Dirac delta function, The bra and ket notation, Linear operators. Observables, The completeness condition, Hermitian operators, Matrix representations, Heisenberg uncertainty principle, Commutators and uncertainty relations, Wave-functions in position and momentum space, Eigenfunctions of Hamiltonian operators.

UNIT-3 **9 L**

Schrodinger Wave Equation: Time-independent and time-dependent Schrödinger wave equation, Eigenvalue problems: particle in a box, the harmonic oscillator; Tunneling through a barrier, Dirac notation for state vectors. Delta function potential, energy eigenkets, Time dependence of expectation values, Spin precession; Schrödinger and Heisenberg picture.

UNIT-4 **9 L**

Theory of Angular Momentum: Quantum theory of orbital angular momentum, Raising and lowering operators, Eigenvalues and Eigenfunctions, Spin angular momentum, Addition of angular momenta, Symmetry, Invariance and conservation laws, Relation between rotation and angular momentum, commutation rules, Matrix representations, Clebsch-Gordan coefficients, Pauli spin matrices, Schrodinger Equation in Spherical Polar Coordinate, Hydrogen atom.

Reference Books:

1. Modern Quantum Mechanics: **J.J. Sakurai**, Pearson Education (LPE), 2017.
2. Introduction to Quantum Mechanics: **David J. Griffiths** Cambridge University Press, 2016.
3. Quantum Mechanics: Concept and Applications: **N. Zettili** Wiley, 2009.
4. Principles of Quantum Mechanics: **R. Shankar**: Springer, 1994.
5. Quantum Mechanics: Theory and Applications:**A.Ghatak and S. Lokanathan** Macmillan, 2004.
6. Quantum Mechanics: **B. C. Reed**, Jones & Bartlett, 2010.
7. A Text book of Quantum Mechanics**, P.M. Mathews and K. Venkatesan**, Tata McGraw Hill.

Course Outcomes: Students will be able to:

CO1	Understand the concepts and methods in quantum mechanics.
CO2	Explore with different formalism of quantum mechanics, approximate methods and angular momentum algebra.
CO3	Understand the foundation equations and experiments.

Course Code PHPC 505	Mathematical Physics	Credits 3-0-0: 3

Course Educational Objectives :

CEO1	To train the students in the mathematical methods which are routinely used in the study of Physical Sciences.
CEO1	Will help the students in understanding the fundamentals of mathematical methods and how to use them in problems routinely encountered in Physics.
CEO1	Will be familiar with vectors, complex analysis, Fourier series, integral transforms and special functions.

UNIT-1 **10 L**

Delta and Beta-Gamma Functions: Dirac delta function, Delta sequences for one-dimensional function, properties of the delta function, Gamma function, factorial notation and applications, Beta function.
Linear Vector Space and Matrices: Definition of Linear Vector Space, Basis and dimension, Scalar Product, Orthogonal And Orthonormal Basis, Gran-Schmidt orthogonalization, Linear operators, Matrices; Orthogonal, Unitary and Hermitian matrices, Eigenvalue and Eigenvectors, diagonalization, Hermitian and Unitary operator, Infinite dimensional space, Hilbert space, Linear vector space.

UNIT-2 **8 L**

Complex Variables: Functions of Complex Variable, Cauchy-Riemann conditions, Cauchy Integral Theorem, Cauchy Integral Formula, Taylor and Laurent Series, Singularities and their classification, The Residue Theorem, Evolution of Integral Using Residue Theorem, Singularity and Branch cut.

UNIT-3 **8 L**

Fourier series and Integral Transforms: Fourier series, Dirichlet conditions. Fourier transforms Development of the Fourier integral, Inversion theorem, Momentum representation.
Laplace transforms: Laplace transforms of derivatives, and Properties of Laplace transform, Inverse Laplace transformation. Applications**.**

UNIT-4 **10 L**

Special Functions: Bessel's functions: Bessel's functions of first and second kind, Spherical Bessel function. Legendre functions: generating function, recurrence relations and special properties, orthogonality, and various definitions of Legendre polynomials. Associated Legendre functions: recurrence relations, parity, orthogonality, Hermite functions, Laguerre functions.

Reference Books:

1. Mathematical Methods for Physicists: **G. Arfken and H.J.Weber** (Academic Press,San Diego) 7th edition, 2012.
2. Mathematical Physics: **P.K.Chattopadhyay** (WileyEastern,NewDelhi), 2004.
3. Mathematical Physics: **A.K.Ghatak, I.C.Goyal and S.J.Chua** (MacMillan,India,Delhi), 1986.
4. Mathematical Methods in the Physical Sciences–**M.L.Boas**(Wiley,NewYork)3rd edition, 2007.
5. Special Functions: **E.D.Rainville** (MacMillan,NewYork), 1960.

Course Outcomes: Students will be able to:

CO1	Understand Linear vector calculus. They will learn about the general coordinate transformation and the relevant transformation equations.
CO2	Familiar with various special functions, solve corresponding differential equations and learn about their properties.
CO3	Familiar with the Fourier series and Laplace transformation and apply the learned concepts to some well-known examples.

Course Code PHPC 507	Electrodynamics	Credits 3-0-0: 3

Course Educational Objectives :

CEO1	The course will enable the students to understand various laws of Electrostatics and Magneto statics including boundary value problems.
CEO1	Maxwell Equations for understanding propagation of electromagnetic waves in various media.
CEO1	It will also help the student to understand the origin of the electromagnetic radiations from an accelerating charge particle.

UNIT-1 **10 L**

Electrostatics and its applications: Electric field and electric potential, Electric dipole and multipole expansion, Divergence and curl of electric field and application of Gauss law, Poisson and Laplace equations in Cartesian and spherical polar coordinates, Electrostatic boundary conditions, Electrostatic energy- potential energy of a point charge and group of point charges-energy density of an electrostatic field, Force and torques, Conductors: Induced charges, Surface charge and force on conductors, capacitors, Electric fields in dielectric media, Polarization.

UNIT-2 **8 L**

Electrostatic boundary value problems with Green's function: Method of Images–Point charge near the grounded conducting sphere, insulated conducting sphere, conducting sphere in a uniform electric field, Green function for the sphere, general solution for the potential,

Magneto statics: Biot-Savart law, Ampere's circuital theorem, Divergence and curl of magnetic field, Applications of Ampere's law, Magnetic vector potential, Boundary conditions, Magnetic field in matter, Electromotive force, Electromagnetic induction, Faraday's law of induction, self-inductance and mutual inductance magnetic energy of steady current distributions. Conservation laws, Equation of continuity.

UNIT-3 **9 L**

Potentials and Fields: Maxwell equations in vacuum and medium, Displacement current, Vector and scalar potentials, Gauge transformations, Coulomb and Lorentz gauges, Green's function for wave equation, Retarded Potential, Jefimenko equations, Lienard-Wiechart potentials, field of moving point charges, Power radiated by a moving point charge, electromagnetic energy and momentum, Poynting vector, Electric and magnetic dipole radiation. Lorentz invariant, Field tensors, Relativistic potentials.

UNIT-4 **9 L**

Electromagnetic Waves: Plane waves in a dielectric medium, Plane waves in conducting media,
Propagation of electromagnetic waves, Reflection and refraction at dielectric interfaces, Complex Fresnel coefficients – reflection from a conducting plane, Reflection and transmission by a thin layer- interference, Dispersion relations in plasma, Optical dispersion in materials; dielectric constant and anomalous dispersion, Frequency dependence of permittivity; Electromagnetic radiation: Radiation from moving charges and dipoles. Transmission lines and waveguides.

Reference Books:

1. **John R. Reitz, Frederic J. Milford and Robert W. Christy,** Foundations of Electromagnetic Theory,3rd Edition, Narosa Publishing House, New Delhi. 2012.
2. **D.J. Griffiths**, Introduction to Electrodynamics. 4th Edition, PHI Learning, New Delhi. 2012.
3. **J.D. Jackson**, Classical Electrodynamics. 3rdEdition,Wiley India.1998.
4. **Jordan E.C. and Balmain K. G.**, Electromagnetic Waves and Radiating Systems, 2nd Edition, Prentice Hall.

Course Outcomes: Students will be able to:

CO1	Learn Fundamentals and applications of various laws of electricity and magnetism.
CO2	Solve Maxwell equations in free space and for harmonically varying fields.
CO3	Solve Electromagnetic wave equations in conducting as well as in non-conducting media.

Course Code PHPC 509	Nuclear and Particle Physics	Credits 3-0-0: 3

Course Educational Objectives :

CEO1	To give understanding of basics of atomic nuclei and nuclear forces.
CEO1	To gain knowledge about origin of different types of radiation decay theories.
CEO1	To develop the understanding of nuclear energy and nuclear reactors for energy generation.

UNIT-1 **8 L**

Properties of nuclei: Nuclear radii and measurements, nuclear binding energy, nuclear moments and systematic, wave-mechanical properties of nuclei, Hyperfine structure, effect of external magnetic field, Nuclear magnetic resonance. Nuclear forces, types of nuclear potential, Ground and excited states of deuteron, dipole and quadruple moment of deuteron, n-p scattering at low energies, Scattering length, spin-dependence of n-p scattering, effective-range theory, coherent and incoherent scattering, p-p scattering, meson theory of nuclear forces, Deuteron problem.

UNIT-2 **10 L**

Radio Active Decays: Kinematics of alpha-decay, naturally occurring decay chains, Range of alpha particles (Bragg Curve), Geiger-Nuttal law, Gammow's theory of alpha decay.

Beta decay and electron capture, Neutrino hypothesis, Energy relations and Q-valuesin beta decays, Fermi theory of beta decay, Kurie plots, Comparative half-life, Classification of beta transitions, selection rules for allowed and forbidden transitions, violation of parity conservation, Electric and magnetic multipole gamma transitions, selection rules, Internal Conversion process, Transition rates, directional correlation in gamma emission.

UNIT-3 **8 L**

Nuclear Models: The Liquid drop model, semi-empirical mass formula, Shell model, Physical concepts of the unified model.

Particle Accelerators: Cosmic rays, radioactive sources, Accelerators: Vande Graff, Tandem, LINAC, 15UD Pelletron, Cyclotron and Betatron, Ion sources, Applications of accelerators in research and Technology. Synchrotron radiation: Polarization, coherence and emittance.

UNIT-4 **10 L**

Particle Physics: Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, the Eightfold way, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics, Introduction to Standard Model of Particle Physics.

Reference Books:

1. **Irving Kaplan**, Nuclear Physics, Narosa, 2002.
2. **K. Hyde**, Basic Ideas and Concepts in Nuclear Physics, Institute of Physics, 2004.
3. **Herald Enge**, Introduction to Nuclear Physics, Addison-Wesley, 1971.
4. **M.K. Pal**, Theory of nuclear structure, affiliated East-Wast Press, 1982.
5. **P.E. Hodgson**, Nuclear reaction and nuclear structure, Clarendon Press, 1971.
6. **W. J. Price**, Nuclear Instrumentation, Tata McGraw Hill, 1964.

Course Outcomes: Students will be able to:

CO1	Understand different types of radiation sources.
CO2	Improve regarding origin of radiation and its applications.
CO3	Understand the production of energy using reactors.

Course Code PHPC 511	Physics Lab	Credits 0-0-6: 3

Course Educational Objectives:

CEO1	To familiarize with the operation of basic laboratory instruments and will gain practical knowledge for the laboratory procedures and techniques.
CEO2	To learn steady and dynamic phenomena along with instruments' calibration
CEO3	To be able to used computer-controlled instruments and data acquisition.

S. No. Experiments

1. Determination of thickness of thin films using optical method.
2. Determination of intrinsic carrier concentration and mobility in a semiconductor using Hall method.
3. Determination of Planck's constant and work functions of different materials.
4. To study the temperature dependence of a semiconductor's resistivity and determine its bandgap.
5. To study the thermo-luminescence phenomenon in a phosphor and compute Quantum yield at different temperature.
6. Determination of magneto-resistance for the given semiconductor.
7. Study the ferromagnetic behaviour and compute energy losses of a ferromagnetic material.
8. Study the I-V and P-V characteristics of a photovoltaic module to determine the maximum power point and efficiency of a solar cell.
9. To verify the inverse square law for Gamma rays with sodium Iodide based Scintillation Counter using (i) Single channel analyser, and (ii) Multichannel analyser.
10. To study the energy calibration of the sodium iodide (NaI) based gamma-ray scintillation detector with different sources.
11. Ultrasonic Interferometer (measurement of velocity of sound in solids and liquids)
12. To study the colorimeter for the determination of concentration of the given solution.
13. Optical Fibre Characterization: (i) Loss measurement, (ii) Numerical Aperture of the fibre, and (iii) Bend losses.

Reference Books:

1. Physics lab manual provided at M.Sc. Lab, Department of Physics, NIT Kurukshetra.

Course Outcomes: Students will be able to:

CO1	Familiarize with the operation of basic laboratory instruments and will gain practical knowledge for the laboratory procedures and techniques.
CO2	Measure steady and dynamic phenomena and calibrate instruments.
CO3	Utilize computer-controlled instruments and data acquisition techniques.

Course Code PHPC 513	Computational Physics Lab	Credits 0-0-4: 2

Course Educational Objectives :	
CEO1	To give some hands-on experience learning various computational methods in Physics.
CEO2	To Provide training to apply real time problems numerically.
CEO3	Application of Computational Methods in Physics.

S. No. Experiments

1. Write a Matlab code to generate Fibonacci Numbers and golden spiral.
2. Least Chi-Squre fitting of linear and non-linear functions to a given experimental data sets and its Likelihood.
3. Solve time independent Schrodinger equation for the 1D potential box and print spectrum of modes using Matlab.
4. To find the equation of motion for a simple pendulum with graphical output and draw the phase space diagram using Matlab.
5. Determine the decay and half-life of Radioactive Nucleus using Mathematica.
6. Write a Matlab code to find out eigenvalues of the given vectors and inverse of the vectors.
7. Software basics geometry and materials using wave optics module in COMSOL Multiphysics, Messing a model.
8. Determination of effective refractive indices of various propagating modes in optical fiber.
9. Determination of propagation loss in the optical fibers and waveguides.
10. Determination of Dispersion of various modes propagating in waveguides.

Reference Books:

1. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers-- RudraPratap, Oxford University Press.
2. COMSOL Multiphysics-- https://www.comsol.com/

Course Outcomes: Students will be able to:	
CEO1	Write code in programing languages to build up some logic to solve Physics problems.
CEO2	Use some advance language and functions/modules therein for solving simulation models, analysis and simulation verification.
CEO3	Perform analytical integrations as well as numerical integrations using software.

Syllabus of Non-Conventional Institute Core (Sports)

Course Code: SWNC101	L	T/P	C
Course Title: Physical Education & Sports	0	2	1

Course Objective

Physical Education and Sports develop confidence, contributing to academic performance and mental health. Physical activity is a great way to relieve stress, promoting positive physical and mental health and enhanced learning aptitude. The class duration of 90 minutes will be divided into 02 segments comprising of Units 1 and 2.

- First 30 minutes of the class will be an interactive session where the students will be oriented and introduced to the different aspects of Physical Education and Sports.
- In the next 60 minutes of the class every student shall practice different skills and techniques of Athletics comprising of Track and Field events or any other specific games/sports of their choice.

Syllabus

Unit 1

Introduction to Physical Education

- Meaning & definition of Physical Education
- Aims & Objectives of Physical Education

Sports awards and honours

- Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)

Olympic Movement

- Ancient & Modern Olympics (Summer & Winter)
- Olympic Symbols, Ideals, Objectives & Values

Physical Fitness, Wellness & Lifestyle

- Meaning & Importance of Physical Fitness
- Components of Physical fitness
- Components of Health related fitness Meaning & Importance of Wellness, Components of wellness
- Preventing Health Threats through Lifestyle Change
- Concept of Positive Lifestyle: Importance of Balance Diet etc.

Fundamentals of Anatomy & Physiology in Physical Education and Sports

- Define Anatomy, Physiology & Its Importance
- Effect of exercise on the functioning of Various Body Systems. (Circulatory System, Respiratory System, Neuro-Muscular System etc.)

Kinesiology, Biomechanics & Sports

- Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports
- Biomechanical principles & its application in sports. (Laws of motion, Friction, Projectile etc.)

Postures

- Meaning and Concept of Postures.
- Causes of Bad Posture.
- Advantages & disadvantages of weight training.
- Concept & advantages of Correct Posture. Common Postural Deformities – Knock Knee; Flat Foot; Round Shoulders; Lordosis, Kyphosis, Bow Legs and Scoliosis, Corrective Measures for Postural Deformities

Training and Planning In Sports

- Meaning of Training
- Warming up and limbering down
- Skill, Technique & Style

Psychology & Sports

- Definition & Importance of Psychology in Physical Edu. & Sports
- Define & Differentiate Between Growth & Development
- Adolescent Problems & Their Management
- Emotion: Concept, Type & Controlling of emotions
- Meaning, Concept & Types of Aggressions in Sports.

Doping

- Meaning and Concept of Doping
- Prohibited Substances & Methods
- Side Effects of Prohibited Substances

Sports Medicine

- First Aid – Definition, Aims & Objectives.
- Sports injuries: Classification, Causes & Prevention and Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries

Unit-2

(Practical-Sports Specific) Each student has to compulsorily opt for one game/sport so that he/she can be assessed on their performance in the same accordingly for all the 03 years.

Each student will be given practical knowledge about the basic fundamentals of various games and sports and Athletic Events be it Track or Field thereby developing the skill.

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball etc.

1. History of the Game/Sport.
2. Latest General Rules of the Game/Sport.
3. Specifications of Play Fields and Related Sports Equipment.
4. Important Tournaments and Venues.
5. Sports Personalities.
6. Proper Sports Gear and its Importance

REFERENCE BOOKS:

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Health and Physical Education – NCERT

Distribution of Marks: Total 100 (10+30+20+40)

1. Class Attendance / Punctuality – 10 marks
2. Active Participation Sports Related Activities - 30 marks
(CITIUS, RUN FOR Unity, Prabhat Pheri etc.)
3. Viva/Subject Knowledge- 20 marks
4. Practical Exam at the end of 6th Sem (Modified Fitness Test)- 40 marks

Note – PWD Students will be exempted from taking part in physical activities and the Modified Physical Fitness Test.

Syllabus of Non-Conventional Institute Core **(Yoga)**

Course Code: SWNC101	L	T/P	C
Course Title: Yoga	0	2	1

Introduction: Yoga education in Institute can immensely contribute to health of children by disseminating knowledge and awareness about the value of health, inculcating and nurturing health promoting habits and life style.

Objectives of the course:

- To enable the student to have good physical and mental health.
- To improve cognitive ability.
- To improve the level of consciousness.

UNIT-I

Introduction to Yog

- Brief introduction to origin of Yog, Psychological aspects leading to origin of Yog, Hindu Mythological concepts about origin of Yog
- History and Development of Yog
- Etymology and Definitions of Yog, Aim and Objectives of Yog, Misconceptions about Yog, TrueNature of Yog
- General Introduction to Schools of Yog
- Principles of Yog, Yog Practices for Health and Harmony

UNIT-II

Yog and You

- **Concept of Health-** Aahaar, Nidra, Bharmacharaya, Viyayaam.
- **Aarogya -** Prevention, Cure and Remedies.
- Life Management and Development.

UNIT-III

Yog for Health Promotion –

- Brief introduction to human body
- Role of yog for health promotion
- Yogic attitudes and practices
- Holistic approach of yog towards the health and diseases
- Introduction to yog diet and its relevance and importance in yog Sadhana
- Dincharya and Ritucharya with respect of yogic lifestyle

UNIT-IV

Yog as Preventive measure for Lifestyle Disease

- **Obesity:** Procedure, Benefits & Contraindications for Tadasana, Katichakrasana, Pavanmuktasana, Matsayasana, Halasana, Pachimottansana, Ardha – Matsyendrasana, Dhanurasana, Ushtrasana, Suryabedhan pranayama.
- **Diabetes:** Procedure, Benefits & Contraindications for Katichakrasana, Pavanmuktasana,Bhujangasana, Shalabhasana, Dhanurasana, Supta-vajarasana, Paschimottanasana, Ardha-Mastendrasana, Mandukasana, Gomukasana, Yogmudra, Ushtrasana, Kapalabhati.
- **Asthma:** Procedure, Benefits & Contraindications for Tadasana, Urdhwahastottansana, UttanMandukasana, Bhujangasana, Dhanurasana, Ushtrasana, Vakrasana, Kapalbhati, Gomukhasana Matsyaasana, Anuloma-Viloma.
- **Hypertension:** Procedure, Benefits & Contraindications for Tadasana, Katichakransan, Uttanpadasana, Ardha Halasana, Sarala Matyasana, Gomukhasana, UttanMandukasana, Vakrasana, Bhujangasana, Makarasana, Shavasana, Nadishodhanapranayam, Sitlipranayam.

UNIT-V (Yogic Practice)

1. YOGIC SUKSMA VYAYAMA

Uccharana-sthalatatha Vishudha-chakra-shuddhi (for throat and voice)
Prarthana (Prayer)
Buddhi-tatha-dhritishakti-vikasaka (for developing will power)
Smaranashakti-vikasaka (for improving the memory)
Medhashakti-vikasaka (for improving the intellect and memory)
Netrashakti-vikasaka (for the eyes)
Kapolashakti-vardhaka (for the cheeks)
Karnashakti-vardhaka (for the ears)
Grivashakti-vikasaka (for the Neck)
Grivashakti-vikasaka (for the Neck)
Grivashakti-vikasaka (for the Neck)
Skandha-tatha-bahu-mulashakti-vikasaka (for the shoulders)
Bhuja-bandhashakti-vikasaka
Kohinishakti-vikasaka
Bhuja-vallishakti-vikasaka
Purna-bhujashakti-vikasaka (for the arms)
Mani-bandhashakti-vikasaka
Kara-prsthashakti-vikasaka
Kara-talashakti-vikasaka
Anguli-mulashakti-vikasaka (for the fingers)
Anguli- shakti-vikasaka (for the fingers)
Vaksa-sthalashakti-vikasaka (for the chest)
Vaksa-sthalashakti-vikasaka (for the chest)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarasakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Udarashakti-vikasaka (for the abdomen)
Kati shakti-vikasaka (for the waist)

Kati shakti-vikasaka (for the waist)
Kati shakti-vikasaka (for the waist)
Kati shakti-vikasaka (for the waist)
Kati shakti-vikasaka (for the waist)
Muladhara-chakra-suddhi (for the rectum)
Upasthatatha-svadhisthana-chakra-suddhi (for the genital organs)
Kundalinishakti-vikasaka (for the kundalini)
Janghashakti-vikasaka (for the thighs)
Janghashakti-vikasaka (for the thighs)
Janushakti-vikasaka (for the knees)
Pindalishakti-vikasaka (for the calves)
Pada-mulashakti-vikasaka
Gulpha-pada-pristha-pada-tala-shakti-vikasaka (for the ankles and the feet)
Padangulishakti-vikasaka (for the toes)

2. YOGSANA (Sitting Postures)

Dandasana, Swastikasana, Padmasana,Vajrasana, Supta Vajrasana**,** Kagasana, Utkatasana, Gomukhasana,Ushtrasana, Shashankasana, Janusirasana, Paschimottanasana, Bhramacharyasana, Mandukasana, Utthana Mandukasana, Vakrasana, Ardha Matsyendrasana, Marichayasana, Simhasana

3. YOGSANA (Supine lying Postures)

Pavanamuktasan, Utthana-padasana, Ardha Halasana, Halasana, Setubandha Sarvangasana, Sarvangasana, Matsyasana, Chakrasana, Shavasana

4. YOGSANA (Prone lying Postures)

Makarasana, Bhujangasana, Shalabhasana, Dhanurasana, Kapotasana, Raja Kapotasana

5. PRANAYAMA (with Antar & Bahya Kumbhaka)

Surya-bhedi and Chandra-bhedi Pranayama, Ujjayi Pranayama, Sheetali Pranayama, Shitkari Pranayama, Bhastrika Pranayama

6. BANDHA

Jivha Bandha, Jalandhara Bandha, Uddiyana Bandha, Mula Bandha, Maha Bandha, Tri Bandha

7. PRACTICES LEADING TO MEDITATION

Ajapa Dharana, Yog Nidra, Practices leading to Breath Meditation, Practices leading to Om Meditation

8. YOGSANA

Siddhasana, Bhadrasana, Baddha Padmasana, Uttitha Padmasana, Bhunamanasana,

Hanumanasana, Bakasana, Kukkutasana, Garbhasana, Matsyendrasana, Marjariasana, Padangusthasana, Hastapadangusthasana, Garudasana, Vatayanasana, Natarajasana, Mayurasana, Padma Mayurasana, Sirshasana and its variations, Ekapada and Dwipada Kandarasana

9. **MUDRAS**

Yog Mudra, Maha Mudra, Shanmukhi Mudra, Shambhavi Mudra, Kaki Mudra, Tadagi Mudra, Vipareet Karni Mudra, Simha Mudra

Distribution of Marks: Total 100 (10+30+20+40)

1. Class Attendance / Punctuality –	**10 marks**
2. Active Participation in Sports Related Activities -	**30 marks**
3. Viva/Subject Knowledge-	**20 marks**
4. End Semester Practical Exam (Yogic Practice)-	**40 marks**

Course Code PHPC 502	Advanced Quantum Mechanics	Credits 3-0-0: 3

Course Educational Objectives :	
CEO1	to enable the students to understand the basic techniques & methods of quantum mechanics
CEO2	Student will be made familiar with, scattering theory, perturbation theory and relativistic quantum mechanics
CEO3	Students may apply these methods in various fields of research and development.

UNIT-1 **10 L**

Perturbation Theory: Time-independent perturbation theory for non-degenerate and degenerate states. First and second-order perturbation, Applications to the anharmonic oscillator, The fine structure of Hydrogen atom, Normal and anomalous Zeeman effect, Hyperfine splitting.

UNIT-2 **8 L**

Variational Principle: Introduction to variational Principle, Ground state energy of one-dimensional Harmonic Oscillator, Delta function potential, Infinite Square well, Quadratic Potential. The ground state of Helium.

UNIT-3 **10 L**

WKB Approximation: Introduction to WKB approximation, Classical region, Potential well with two vertical walls, variational Step potential with tunnelling, Gamow's Theory of Alpha decay.

Time-Dependent Perturbation Theory: Time-dependent perturbation theory, transition probability, constant and harmonic perturbation, Fermi golden rule, Electric dipole radiation and selection rules. Applications—Zeroth order, first order, second order, two-level systems, Spontaneous emission, Einstein's A and B coefficient.

UNIT-4 **8 L**

The Adiabatic Approximation: The Adiabatic Theorem, Problems of time-dependent potential wells. Applications. **Scattering:** Classical Scattering Theory, Partial Wave analysis for Spherically Symmetric potential, The Born approximation.

Reference Books:

1. **S. Gasiorowicz**, Quantum Physics, Wiley, 2007.
2. J**.J. Sakurai**, Modern Quantum Mechanics, Pearson Education (LPE), 2017.
3. **David J. Griffiths**, Introduction to Quantum Mechanics, Cambridge University Press, 2016.
4. **R. Shankar**, Principles of Quantum Mechanics, Springer, 1994.
5. **B. C. Reed,** Quantum Mechanics**,** Jones & Bartlett, 2010.

Course Outcomes: Students will be able to:	
CO1	Learning how scattering amplitude and scattering cross-section are related to each other.
CO2	Demonstrate fundamental knowledge of relativistic quantum mechanics and quantum field theory.
CO3	Develop second quantization method for free fields.

Course Code PHPC 504	Solid State Physics	Credits 3-0-0: 3

Course Educational Objectives:	
CEO1	To familiarize the students about the fundamentals of Solid State Physics.
CEO1	To develop understanding of crystal structures, defects, thermal and electronic properties of solids.
CEO1	To develop understanding of classification of various condensed matter systems

UNIT-1 **10 L**

Crystal Physics: Crystalline and non-crystalline solids, Bonding in solids- Ionic; covalent and metallic solids; Van-der Waals interaction; hydrogen bonding, Bravais lattice; lattice planes and directions; typical crystal structures, Reciprocal lattice; Bragg's law of diffraction; structure factor, Defects and dislocations- Point defects- Frenkel and Schottky defects, colour centers, excitons. Dislocations- models of screw and edge dislocations. Surface imperfections- grain boundaries, tilt boundaries, twin boundaries and stacking faults, Volume defects, Quasi Crystals, Liquid Crystals.

UNIT-2 **8 L**

Lattice Vibrations and Thermal Properties: Monoatomic and diatomic lattices, normal modes of lattice vibration, phonons and density of states, dispersion curves, specific heat- classical, Einstein and Debye models, Electronic contribution to specific heat. Thermal expansion, thermal conductivity, Seebeck effect, Peltier effect, Thomson effect.

UNIT-3 **8 L**

Electronic and Transport Properties: Classical Free Electron (Drude–Lorentz) theory, Electrical Conductivity, mobility, Sommerfeld Free Electron Theory, Concept of Fermi level, Fermi-Dirac distribution function, Charge carrier density, Thermal Conductivity, Wiedemann-Franz law, Motion of electron in a magnetic field: cyclotron resonance and Hall effect, Failures of free electron theory.

UNIT-4 **10 L**

Energy Band Theory: Energy spectra of atoms, molecules and solids- formation of energy bands, Kronig-Penny Model, Wave equation of electron in periodic potential, Bloch theorem and crystal momentum, E-K diagram, Brillouin Zones, construction of Brillouin zones- extended, reduced and periodic zone schemes, effective mass of an electron, nearly free electron model, tight binding approximation, Classification into metals, semiconductors and insulators.

Reference Books:

1. **Kittel, C**., Introduction to Solid State Physics, Wiley, 2007.
2. **Ashcroft and Mermin**, Solid state Physics, Thomson, 2007.
3. **Ali Omar,** Elementary Solid State Physics, Addison-Wesley, 2005.
4. **M A Wahab,** Solid State Physics-Structure and Properties of Materials, Narosa, 2005.

Course Outcomes: Students will be able to:	
CO1	Understand the basics of crystal structures, crystal structure determination, crystal defects and their role in various applications.
CO2	Predict electronic and thermal properties of materials and explain their origin.
CO3	Explain the concept of energy bands and effect of the same on electronic properties and classification of various condensed matter systems.

Course Code PHPC 506	Thermodynamics and Statistical Physics	Credits 3-0-0: 3

Course Educational Objectives :

COE1	To understand the fundamental aspects of Statistical Physics and thermodynamical properties.
COE2	To understand the behavior of thermodynamical system in terms of macroscopic and microscopic variables.
COE3	To construct statistical formalism for fermion as well as bosonic system and analyze their properties.

UNIT-1 **10 L**

Fundamental Concepts: Basic concepts and definitions. State variables and equations of state. Work, heat, and energy. Laws of thermodynamics and their significance. Thermodynamic potentials: Maxwell relations. Significance of entropy. Need for statistical physics, models of macroscopic systems, Macroscopic and Microscopic states, Phase space, Liouville's theorem, energy quantization, Probability distributions, Boltzmann's principle, Partition function, Ensembles: Micro-canonical, canonical, and grand canonical. Statistical interpretation of entropy.

UNIT-2 **8 L**

Classical Statistics: Maxwell-Boltzmann distribution, Equipartition theorem, Virial theorem, Langevin and Brillouin functions, Applications: Specific heat of gases, Real gases, Paramagnetism, Curie's law, Nuclear spins, Ortho and para hydrogen, Negative temperature concept, System of harmonic oscillators

UNIT-3 **10 L**

Bose Einstein and Fermi Dirac Statistics: Systems of identical, Indistinguishable particles, Spin and symmetry of wave functions, Bosons, Fermions, Pauli's exclusion principle, Bose-Einstein and Fermi-Dirac distributions, Degeneracy, Ideal Fermi gas and ideal Bose gas, Applications of Bose Einstein and Fermi Dirac Statistics –Statistical treatment of blackbody radiation, Liquid helium, Free electron gas and its behaviour, Specific heat of crystalline materials – Einstein and Debye theories.

UNIT-4 **8 L**

Phase Transitions and Critical Phenomena: Introductory ideas on phase transitions, Phase equilibrium and phase diagrams, First order phase transition: Theory of Lang and Lee, Dynamical model of phase transitions: Weiss theory of ferromagnetism, Second order phase transition: Landau theory, Order parameter and Landau free energy expansion, Critical point exponents. Transfer matrix approach.

Reference Books:

1. **R. K. Pathria,** Statistical Mechanics (II Ed.), Butterworth-Heinemann, 1996.
2. **Kerson Huang**, Statistical Mechanics, II Ed, John Wiley, 1987.
3. **Herbert B. Callen,** Thermodynamics (II Ed.) Wiley, 1985.
4. **E. Atlee Jackson,** Equilibrium Statistical Mechanics, Prentice-Hall, 1968.
5. **F. Reif,** Fundamentals of Statistical and Thermal Physics, McGraw-Hill, 1985.

Course Outcomes: Students will be able to:	
CO1	Develop the concept to understand the thermodynamical many particles system in terms of microscopic and macroscopic variables.
CO2	Apply statistical mechanics as a tool to investigate Fermionic system as well as bosonic system.
CO3	Understand new state of matter called Bose-Einstein Condense states for bosonic system.

Course Code PHPC 508	Electronics	Credits 3-0-0: 3

Course Educational Objectives :

COE1	To familiarize the students about Bias the transistors and FETs for amplifier applications.
COE2	To develop understanding of design op-amp circuits to perform arithmetic operations.
COE3	To develop understanding of design simple analog circuits.

UNIT-1 **9 L**

Active and Passive Components: Resistors, capacitors and Inductors**,** Thevenin's, Norton's and superposition theorems; Diodes and its applications: Rectifiers, Clippers and Clampers, Voltage multipliers, Bipolar Junction Transistors (BJT): Characteristics, parameters and configurations, Field Effect Transistors: JFET and MOSFET Characteristics.

UNIT-2 **9 L**

Amplifiers: Classification of Amplifiers, Cascading of amplifiers, Types of power amplifiers, Amplifier characteristics, Feedback in amplifiers, Feedback amplifier topologies, Effects of negative feedback;
Operational Amplifiers: Basics, Feedback, Mathematical operations, Circuits and Applications;
Oscillators and Multivibrators: Classification and basic principle of oscillator, Feedback concepts, Types of oscillator, Classes of multivibrators, The 555 Timer.

UNIT-3 **9 L**

Boolean algebra: Number system, binary codes, DeMorgan's Theorem;
Logic Operations/Gates : OR, AND, NOT, NAND, NOR, XOR, XNOR)**;**
Minimization of logic functions: Karnaugh map (K-map), K-map reduction and logic function implementation, K-maps for SOP, POS.

UNIT-4 **9 L**

Digital Circuits: Combinational circuits: Adder, Multiplexer, DE multiplexer, Encoder, and Decoder; Clock and timing circuits**:** Clock waveform, Schmitt Trigger, 555 Timer-A stable and Monostable; Sequential logic elements: Flip-Flops (SR, J-K, Master slave, T-flip flops etc.), Registers and counters, D/A and A/D conversions.
Microprocessor and Microcontroller Basics: Introduction, Outline of 8085/8086 processor, Data analysis.

Reference Books:

1. **J. Millman & Grable**, Microelectronics, McGraw Hill, 2017.
2. **Malvino and Leach**, Digital Principles & Applications, II edition, McGraw Hill, 2017.
3. **J. D. Ryder**, Electronic fundamental and applications, Prentice Hall India, 1975.
4. **Ramesh S. Gaonkar** , Microprocessor Architecture, Programming and its Applications with the 8-85/8080A latest edition, Penram International, 2000.
5. **Fraser**, Telecommunications, CBS Publisher, 2019.

Course Outcomes: Students will be able to:	
CO1	Illustrate the basic concepts and applications of different modern electronic devices.
CO2	Apply fundamental concepts of digital electronics for construction of logic circuits.
CO3	Design different active and passive electronic circuits such as amplifiers and oscillators.

Course Code PHPC 510	Atomic and Molecular Physics	Credits 3-0-0: 3

Course Educational Objectives :

COE1	To understand the fundamental aspects of atomic physics and analysis of spectra
COE2	To understand the behavior of atoms in external applied electric and magnetic
COE3	To construct and analyze the rotational, vibrational spectra of molecules.

UNIT-1 **11 L**

Atomic Physics: Electron spin and vector atom model, Fine structure of hydrogen and hydrogen-like atoms-mass correction, Spectrum of He atom, Spin-orbit term, Darwin term, Intensity of fine structure lines, the ground state of two-electron atoms-perturbation theory and variation method. Many electron atoms- LS and JJ coupling schemes, Lande interval rule. Terms for equivalent & non-equivalent electron atom, Space Quantization: Stern-Gerlach experiment, normal & anomalous Zeeman effect, Stark effect, Paschen-Back effect; Intensities of spectral line: General selection rule, Hyperfine Structure, Isotope Shifts and Nuclear Size Effects, Spectra of Alkali elements.

UNIT-2 **7 L**

Molecular Physics: Rotation and vibration of Diatomic molecules; Interpretation of Infrared and Raman spectra, Electronic structure of diatomic molecules. Description of Molecular Orbital and Electronic Configuration of Diatomic Molecules: H^2, H^{2+}, Co-relation diagram for hetero-nuclear molecules.

UNIT-3 **8 L**

Molecular Spectra: Rotation, Vibration-rotation and electronic spectra of diatomic molecules.The Franck Condon Principle. Raman Spectroscopy: Introduction, pure rotational Raman Spectra, vibrational Raman spectra, Nuclear spin and intensity alternation in Raman spectra, Isotope effect and Raman spectrometer. Dissociation and pre-dissociation, Dissociation energy, Rotational fine structure of electronic bands.

UNIT-4 **10 L**

Electronic and Fluorescence spectroscopy: Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, Intensity of electronic bands-Franck Condon Principle, Dissociation and pre-dissociation, Dissociation energy, Rotational fine structure of electronic bands, The Fortrat-parabole, Electronic structure of diatomic molecules; UV-Visible Absorption spectroscopy, Absorption spectrometer, Fluorescence spectroscopy: Fluorescence and Phosphorescence, Kasha's rule, Quantum Yield, Non-radiative transition, Jablonski diagram, Spectrofluorometer.

Reference Books:

1. **Arthur Beiser**, Concept of Modern Physics, McGraw-Hill Book Company, 1987.
2. **Gerhard Hertzberg**, Atomic spectra & atomic structure, Dover publication, New York, 2003.
3. **G. Aruldhas**, Molecular structure & spectroscopy, Prentice – Hall of India, New Delhi, 2015.
4. **Colin N. Banwell& Elaine**, Fundamentals of molecular spectroscopy, M. McCash, 2020.
5. **H.E. White,** Introduction to Atomic spectra, 1934.
6. **Gerhard Herzberg**, Spectra of diatomic molecules, Vannostrang, 2007**.**
7. **Joseph R. Lakowicz**, Principles of fluorescence spectroscopy, Springer, 2006**.**

Course Outcomes: Students will be able to:

CO1	Distinguish between Normal Zeeman effect and Anomalous Zeeman effect and will understand Hyperfine structure and Lamb shift.
CO2	Explain LS Coupling, J-J Coupling and Paschen Back effect.
CO3	Interpret Infrared Spectroscopy and Rotational Raman Spectra.

Course Code PHPC 512	Electronics Lab	Credits 0-0-6: 3

Course Educational Objectives:	
COE1	To familiarize with the operation of basic laboratory instruments and will gain practical knowledge for the laboratory procedures and techniques.
COE2	To learn steady and dynamic phenomena along with instruments' calibration
COE3	To be able to used computer-controlled instruments and data acquisition.

S. No. Experiments

1. Study the operation of Operational amplifier 741 and to carry out the following experiments:
   (a) Input bias current measurement
   (b) Input offset current measurement
   (c) Gain measurement in both inverting and non-inverting configuration.
   (d) Configure the op-amp as an integrator
   (e) Verification of existence of drift
2. Study the features of an IC integrated timer circuit 555 and use it to setup and operate the following basic circuits:
   (a) A free running a-stable-multivibrator
   (b) A mono-stable-multivibrator
   (c) A long duration multivibrator
3. Study the IC 723 as a current and voltage regulator.
4. Study the frequency response of a low pass filter using FunctionGenerator and CRO.
5. Design and set up a 4:1 Multiplexer (MUX), and design and set up a 1:4 De-multiplexer (DE-MUX) using only NAND gates.
6. Verify the truth table of basic gates (NOT, AND, OR) and universal gates (NAND and NOR).
7. Determine the frequency Signal by comparing the frequencies of two oscillators using Lissajous Figures.
8. Characterization of moving objects with Stroboscope.
9. Measurement of displacement usingLinear Variable Differential Transformer (LVDT) and study its characteristics
10. Study the properties of Temperature controller.
11. Familiarization and Characterizations of Lock-In-amplifier.

Reference Books

1. Electronics lab manual provided at M.Sc. Lab, Department of Physics, NIT Kurukshetra.

Course Outcomes: Students will be able to:	
CO1	Learn how to handle electronic equipment such as DSO, Function generator, Spectrum analyser, etc.
CO2	Design different electronic circuits and study their performances.
CO3	Examine the output results of different electronic components as well as complete circuit.

Course Code PHPC 514	Analytical Instrumentation Lab	Credits 0-0-6: 3

Course Educational Objectives :	
COE1	To familiarize with the operation of basic laboratory instruments and will gain practical knowledge for the laboratory procedures and techniques.
COE2	To learn steady and dynamic phenomena along with instruments' calibration.
COE3	To be able to used computer-controlled instruments and data acquisition.

S. No. Experiments

1. To understand the microstructural features of ceramics/metals by optical microscopy.
2. Complex impedance spectroscopy for electronic property evaluation.
3. To monitor the Reflection and Transmission spectrum of thin film using Charge coupled detector.
4. FTIR study of an inorganic and organic compound.
5. Determine the structure and crystallite size of a material using X-ray diffraction.
6. Measurement of Thermal and Electrical conductivity of metals.
7. Testing of a metal bar using Ultrasonic flaw detector.
8. Determination of potassium activity of unknown sample using 8 K Multi-channels Analyzer with NaI scintillation detector.
9. Record and analyse Photo luminescence spectrum of an inorganic phosphor.
10. Study and analyse the UV visible spectrum of a sample.
11. Study of surface morphology of thin film by scanning electron microscopy (SEM)technique.
12. Study the elemental analysis of a sample using Energy dispersive X-ray Analysis (EDAX).
13. Study the elemental analysis of soil sample using X-Ray Fluorescence (XRF) technique.
14. Determination of electron spin and Lande's 'g' factor.
15. Determination of Proton spin and nuclear 'g' factor

Reference Books

1. Analytical Instrumentation lab manual provided at M.Sc. Lab, Department of Physics, NIT Kurukshetra.

Course Outcomes: Students will be able to:	
CO1	Learn the instrumentation details of the analytical equipment and the importance and function of each individual component.
CO2	Learn how to handle analytical equipment such as SEM, XRD, UV-Vis spectrometer, XRF, FTIR and P-E loop tracer.
CO3	Learn the output data analysis and understand the material properties.