Postgraduate Department of Physics (SF)

Programme for M.Sc Physics from 2015 series

SEM	Course No	Course Name	Hours	Credits	Marks
1	PSP 4401	Mathematical Physics - I	4	4	80
1	PSP 4403	Classical Mechanics	4	4	80
1	PSP 4405	Electrodynamics	5	4	80
1	*PSP 4307/ *PSP 4309	Instrumentation /Renewable energy Physics	4	3	60
1	PSP 4411	Physics Laboratory – I	9	4	80
1	PSP4413	Analog & Physical Electronics	4	4	80
		Total	**30**	**23**	**460**
2	PSP 4402	Quantum Mechanics - I	4	4	80
2	PSP 4404	Statistical Physics	4	4	80
2	PSP 4406	Mathematical Physics - II	4	4	80
2	PSP 4408	Nuclear Physics	5	4	80
2	PSP 4410	Physics Laboratory – II	9	4	80
2	*PSP 4312/ *PSP 4314	Computational Physics /Nano Physics	4	3	60
		Total	**30**	**23**	**460**
3	PSP 5401	Quantum Mechanics –II	5	4	80
3	PSP 5403	Particle Detector and Accelerator	4	4	80
3	*PSP 5311/ *PSP 5313	Interfacing Microcontroller/Crystal growth and Thin films	4	3	60
3	PSP 5405	Condensed Matter Physics-I	4	4	80
3	PSP 5307	Physics Project – I	9	3	60
3	PSP 5409	Spectroscopic Techniques	4	4	80
		Total	**30**	**22**	**440**
4	PSP 5402	High Energy Physics	5	4	80
4	PSP 5404	Digital Electronics	4	4	80
4	PSP 5406	Condensed Matter Physics - II	4	4	80
4	PSP 5308	Physics Project – II	9	3	60
4	*PSP 5310/ *PSP 5312	Matrix & Fourier Optics /Laser and Nonlinear Optics	4	3	60
4	PSP5414	Astrophysics	4	4	80
		Total	**30**	**22**	**440**
		Grand Total for Semester I - IV	**120**	**90**	**1800**

PSP 5401 **Quantum Mechanics – II** **5hr / 4 cr**

Preamble:
Quantum mechanics is essential to understand the behaviour of systems at atomic length scales and smaller. Important applications of quantum mechanical theory include superconducting magnets, light-emitting diodes, laser, transistors, semiconductors such as the microprocessor, medical and research imaging such as magnetic resonance imaging and electron microscopy, and explanations for many biological and physical phenomena.

Objectives:
1. To study the approximation methods for stationary states, evolution of time concepts and their applications.
2. To emphasize advanced topics such as the relativistic quantum mechanics and quantum field theory.

Unit 1:Angular Momentum
Dirac's notation – matrix representation of operators – unitary transformations – matrix theory of Harmonic oscillator – matrix representation of angular momentum operators – spin angular momentum – Non-relativistic Hamiltonian including spin – Addition of angular moments – Clebsch-Gordan coefficients – spin functions for a system of two spin-1/2 particles

Unit 2: Scattering Theory
Wave mechanical picture of scattering – Green's functions – scattering amplitude – Born approximation – Validity of Born approximation – Partial wave analysis – Phase shifts: relation to potential – mutual scattering of two particles.

Unit 3: Approximation Method for Stationary States
Time independent perturbation theory – Non-degenerate – degenerate – Applications – Variation method – Ground state energy – Application to excited states – Exchange interaction – WKB approximation – Applications.

Unit 4: Time dependent Perturbation Theory
Time dependent perturbation theory – Transition probability – Fermi's Golden rule – selection rules – Harmonic perturbations – Interaction of an atom with EM radiation – Dipole approximation – Einstein's coefficients – Equation of motion in Heisenberg's picture – interaction picture.

Unit 5: Relativistic Quantum Mechanics and Quantum Field Theory
Klein-Gordon equation – Dirac equation – Plane wave solutions – spin of the Dirac particle – Dirac particle in EM fields – Dirac equation in central field – spin magnetic moment – Euler-Lagrange's classical field equation – Schrödinger's field – commutation relations for Bosons, anti commutation relation for Fermions.

Text Book(s):

1. G. Aruldhas, "Quantum Mechanics", 2nd ed PHI Learning Private Limited, (2013)
2. Mathews P.M & Venkatesan K. Reprint, "Text book of Quantum Mechanics" (2002) Tata McGraw, Hill, New Delhi,

References:

1. Thankappan V.K "Quantum Mechanics" 2nd Ed" Wiley Eastern Ltd (1993)
2. Schiff L.I. "Quantum Mechanics" 3rd Ed" McGraw Hill New York (1968)
3. Cohen Tannoudji C, Diu B & Laloe F. "Quantum Mechanics", Vol I & II, John Wiley & sons, Inc.

PSP 5403 Particle Detectors and Accelerators 4 hr / 4 cr

Preamble:

Particle Physics, which probes matter on the smallest distance scales requires the use of the highest available particle collision energies. Therefore, for nearly all experimental particle physics programmes, the development of particle detector and accelerator technology has proved essential. Fundamental particle physics explores the nature of matter and of the forces that bind matter together. This field addresses some of the oldest and deepest questions in natural philosophy.

Objectives:

1. To learn the interaction of radiation with matter and different kinds of detector function.
2. To understand the experimental techniques and basic accelerator physics.

Unit 1: Interaction of radiation with matter

Matter Particle interaction – Interaction of high energy particles with matter Energy loss of heavy charged particles in matter – Electronic stopping power (Bohr and Bethe-Bloch formulae) - Energy loss of electrons and positrons: Electronic stopping and energy loss by bremsstrahlung radiation, Interaction of photons: -Hadron interactions, hadron showers.

Unit 2: Particle detectors

General characteristics of detectors: efficiency, response in energy, time, position and corresponding resolutions, recovery time or count rate handling capability.

Unit 3: Detector Types

Gas detectors - Semiconductor detectors - Silicon detectors (surface barrier, Scintillation detectors: Inorganic and organic scintillators, photomultipliers, photodiodes, avalanche photodiodes- Miscellaneous detectors: cryogenic detectors, thermal detectors, channeltrons and microchannel plates, plastic track detectors, hybrid detectors.- Large sized HEP detectors (typical example: CMS, ATLAS, INO)

Unit 4: Experimental techniques

Electronics modules for pulse processing: Preamplifiers (charge, voltage sensitive), amplifiers (spectroscopy or high resolution, fast and timing filter), timing discriminators (leading edge and constant fraction types), gate and delay generators, coincidence (fast and slow) units, linear gate and stretchers, scalars and rate dividers, computer based data acquisition systems (DAQ)

Unit 5: Basic Accelerator Physics

Introduction to accelerators; basic concepts; DC accelerators; Cockcroft – Walton, Van de Graff and tandem -cyclotrons; synchrotrons; intersecting storage rings; ion sources.

Text Book(s):

1. W.R. Leo "Techniques in nuclear & particle physics", 2nd ed, Springer (2005)
2. G. Knoll "Radiation Detection & measurement", 3rd ed, John Wiley & Sons (2007)

References:

1. Fernow, "Introduction to experimental particle physics", Cambridge University Press (1989)
2. T. Ferbel, "Experimental techniques in HEP", World Scientific press (1991)
3. Arvind Jain, "Introduction to Accelerator physics", Macmillan (1993)

PSP 5311 Interfacing Micro-controller 4 hr / 3 cr

Preamble:
Microcontrollers can be used as the 'brain' to control a large variety of products. In order to control a device, it is necessary to interface the device with the microcontroller. This course helps to enable students with electronics experience to successfully complete interfacing tasks.

Objectives:
1. To understand the architecture and principles of operation of a microcontroller
2. To be able to interface a microcontroller to input and output devices.

Unit 1: Architecture of microcontroller

Micro controllers & Embedded Processors: Micro controller versus General-purpose Microprocessors, Microcontrollers for embedded systems, embedded applications, choosing a Microcontroller. 8051 Architecture: 8051 Microcontroller hardware, input/output pins, ports and circuits, external memory, counter and timer, serial data input and output, interrupts, other members of 8051.

Unit 2: 8051 Instructions

Addressing modes: immediate and register addressing modes, accessing memory using various addressing modes. Arithmetic instructions and programs: unsigned addition and subtraction, unsigned multiplication and division, signed members concepts and arithmetic operations.

Unit 3: 8051 programs

Logic and compare instructions rotate and swap instructions. Jump, Loop and call instructions; Loop and jump instructions, call instructions, time delay, generation and calculation. Single bit instructions and programming: single bit instruction programming, single bit operation with carry reading input pins versus port latch. I/O port programming: I/O programming, bit manipulation.

Unit 4: 8051 Timer / Counter, serial communication and interrupts programming

Timer / Counter programming: programming 8051 timers, counter programming, pulse frequency and pulse width measurements. Serial communication programming: Basics of serial communication, 8051 connection to RS232, 8051 serial communication programming. Interrupts programming: Interrupts of 8051; programming timer interrupts, programming external hardware interrupts, and programming serial communication interrupts.

Unit 5: Application of 8051 micro controllers

Programmable peripheral interface (PPI)-8255, programming 8255, 8255 interfacing with 8051 - Interfacing - Key board - LED / LCD- A/D & D/A converters-stepper motor.

Text Book(s):

1. Kenneth J.Ayala "The 8051 Microcontroller–Architecture Programming and Applications" Penram International Publication (1996)
2. Mazidi and Mazidi "8051 Micro controller and Embedded systems" Pearson Education Asia (2002)

Reference:

1. Rajkamal "The concepts and features of micro controllers (68HC11, 8051, 8096)" Wheeler Publications (2000)

PSP 5313 Crystal Growth and Thin Film 4 hr / 3 cr

Preamble:

Crystal growth involves a variety of research fields ranging from surface physics, crystallography, and material sciences to condensed mater physics. Crystal growth plays an important role in both theoretical and experimental research fields, as well as in applications.

Thin films science and technology plays an important role in the high-tech industries. Thin film technology has been developed primarily for the need of the integrated circuit industry. This course emphasizes the importance of thin films and their properties for new technologies and it explains fabrication, characterization and applications.

Objectives:

1. To impart the students hands-on experience of system operation, thin film coating and design.
2. To introduce the students to various crystal growth methods and characterization adopted in industries and scientific laboratories.

Unit 1: Crystal Growth

Nucleation – concept of nucleus formation – shapes of nucleus – phase diagrams phase rules – methods of melt growth –S-R Method– vapour growth – slow cooling – gel growth and etching techniques – crystal pulling – Czochralski process.

Unit 2: Characterization techniques

Geometry of X-ray reflections – interpretation of Laue photographs – method of taking powder photographs – determination of cell dimensions – measurement & determination of intensities of X-ray reflections – measurement of crystal grain size in poly crystalline aggregates. Micro hardness measurements: Mayer's test – Vickers test – knoop test – effect of loading.

Unit 3: Thin Film formation

Thin Film definition- Types of formation of thin films- Physical Vapor deposition-– thermal and sputtering deposition – chemical vapor deposition

Thin film Lab: Low and high vacuum – production and measurement- Pump down characteristics of rotary and diffusion pump, flow rate determination, use of McLeod's gauge, different types of valves and flanges.

Unit 4: Growth and characterization of thin films

Condensation, nucleation, theories of nucleation and growth of thin films – Characterization of thin films- film thickness measuring methods- structure characterization methods – spectrophotometer – STM – AES and XPS. Lab: reflection transmission curves using UV-visible spectrophotometer – determination of n and k values – Optical Eg determination – thickness measurement using crystal and Fizeau method.

Unit 5: Properties and application of thin films

Mechanical, electrical and optical properties - Piezoelectric and piezo-resistive properties - Thin film resistors – optical thin films – antireflection coatings – hard and protective coatings - Hard thin film coating- antireflection coating- transparent conductive coating

Text Book(s):

1) Milton Ohring "Materials of science of thin films deposition and structure", 2nd ed, Academic press (2006).
2) Andrew Guthrie "Vacuum technology", John Wiley & sons, Inc (1963).
3) T. J. Coutts "Electrical conduction in thin metal films", Elsevier scientific publishing company (1974).

References:

1. L.I.Maissel and R.Glang "Handbook of Thin Film Technology" McGraw Hill Book Company New York(1970)
2. K.L.Chopra "Thin Film Phenomena" McGraw Hill Book Company NewYork(1969)
3. P.S.Raghavan and P.Ramasamy, "Crystal Growth Process and Methods" KRU publications, Kovilpatti(2000)
4. N.F.M.Henry, H.Lipson and W.A.Wooster "The Interpretation of X - ray Diffraction Photographs" Macmillan & Co Ltd. London (1969)

PSP 5405 **Condensed Matter Physics-I** **4 hr/ 4 cr**

Preamble:

The field of condensed matter physics explores the macroscopic and microscopic properties of matter. The syllabus explores how matter arises from a large number of interacting atoms and electrons, and what physical properties it has as a result of these interactions.

Objectives:

1. To study how the diverse properties of condensed matter can be related to the interactions at the atomic level.
2. To provide a foundation in crystallography, x-ray diffraction, phonons and band theory.

Unit 1: Crystallography and X-ray diffraction

Basic concepts of Crystallography – Periodic arrays of atoms - crystal structure Fundamental types of lattices – crystal systems- Simple crystal structure - crystal symmetry elements-space groups-Bravais space lattices – Miller indices - Bragg law- diffraction conditions- Laue equation-Brillouin zone- reciprocal lattice – atomic form factor.

Unit 2: Crystal binding

Crystals of Inert gases-Vander Waals – London interaction- ionic crystals-electrostatic or Madelung energy-covalent crystals- metals- hydrogen bonds-analysis of elastic strains and stiffness.

Unit 3: Phonons

Lattice vibrations of crystals with monoatomic crystal- Phonon momentum- Phonon and thermal properties of solids: Einstein and Debye theory of specific heat of solids. Anharmonic crystal interactions- Thermal conductivity

Unit 4: Band theory

Free electron Fermi gas: energy levels in 1-D and 3-D- Heat capacity of the electron gas- Hall effect- Nearly Free electron model- Bloch functions- Kronig Penney model-Band theory of solids.

Unit 5: Semiconductors crystals

Band gap-Effective mass-: silicon and germanium-intrinsic carrier concentration-impurity conductivity-thermoelectric effects-Fermi surfaces and experimental methods in Fermi surface studies (Any two methods).

Text Book:

1. Charles Kittel, "Introduction to Solid State Physics", VII ed, Wiley Eastern Ltd. (2011)

References:

1. S. O. Pillai, "Solid State Physics", Wiley Eastern Ltd., (1994)
2. Leonid Azaroff, "Elements of X-ray crystallographyMcGraw Hill Company " (1968)
3. F. C Philips, "An introduction to crystallography" 4ed, ELB society(1971)
4. M.Ali Omar, "Elementary Solid State Physics" Pearson Education Pvt. Ltd. (2000)

PSP 5307 & PSP 5308 Project Laboratory – I & II 9hr / 3cr

Each student is to submit a project in each III and IV semesters. There will be no other practical work during these semesters. Usually, a project is approved by the staff supervisor/guide. Students shall maintain daily records and present at least two oral progress reports while doing the project. They shall submit the dissertation at the end of each semester (III and IV). All the above process is reckoned for assessment. Topics shall usually be experimental by nature. However, theoretical types may also be admitted in one of the two semesters.

EVALUATION METHOD FOR PROJECT:

1) Project proposal (oral and written)	20%
2) Oral progress reports	20%
3) Continuous assessment	35%
4) Final report	25%

PSP 5409 Spectroscopic Techniques 4 hr/4 cr

Preamble:

Spectroscopic techniques employ light to interact with matter and thus probe certain features of a sample to learn about its consistency or structure. The course presents a higher level of complexity in understanding the biochemical or biophysical characterisation. An understanding of the properties of electromagnetic radiation and its interaction with matter leads to an appreciation of the variety of types of spectra and, consequently, different spectroscopic techniques and their applications to the solution of biological problems.

Objectives:

1. To help students learn the relative merits of the techniques, the operating principles, and develop problem solving skills generally useful in chemical analysis.
2. To know the various aspects of spectroscopic chemical analysis relevant to both research and industry.

Unit 1: Microwave spectroscopy

Interaction of radiation with rotating molecule – Rotational spectra of rigid di- atomic molecules – Isotope effect in rotational spectra – Intensity of rotational line - Non rigid rotator – Linear poly atomic molecules – Symmetric top molecules – Asymmetric top molecules – Stark effect – Microwave spectrometer – Applications of microwave spectroscopy.

Unit 2: Infrared Spectroscopy

Vibrational energy of the diatomic molecule – Infrared selection rules – Vibrating diatomic molecules – diatomic vibrating rotator – vibration band – vibration of poly atomic molecules – Fermi Resonance – Hydrogen bonding – Rotating vibration spectra of a poly atomic molecule – Normal modes of vibration in crystal – Fourier transform infra red spectroscopy – applications.

Unit 3: Raman Spectroscopy

Theory of Raman Scattering – Rotational Raman spectra – Vibrational Raman spectra – Mutual exclusion principle – Raman spectrometer – Polarization of Raman scattered light – Structure determination using IR and Raman Spectroscopy – Raman investigation of phase transition – Proton conduction in solids – Raman spectral – Resonance Raman scattering.

Nonlinear Raman phenomena – Hyper Raman effect – Stimulated Raman scattering – Inverse Raman Effect – Coherent Anti Stokes Raman scattering – Photo acoustic Raman scattering – Multi photon spectroscopy.

Unit 4: Electronic and Mossbauer Spectroscopy

Vibrational coarse Structure – Vibrational analysis of band systems – Franck – Condon principle – Rotation fine structure of electronic vibration spectra – The Fortran parabola – Dissociation – Pre-dissociation – Electronic angular momentum in diatomic molecules – Photo electron spectroscopy – Recoilless emission and absorption – experimental techniques – Mossbauer spectrometer – Isomer shift – Quadra pole interaction – Magnetic hyper fine interaction – applications.

Unit 5: Resonance Spectroscopy

NMR – Magnetic properties of nuclei – Resonance condition – NMR instrumentation – Relaxation processes – Bloch equations – Chemical shift – NMR spectra of solids – Magic angle spinning NMR – Nuclear quadrupole effects – NMR imaging.
ESR – Principle of ESR – ESR spectrometer – Fine and hyper fine structure – Double resonance in ESR

Text Book(s):

1. N.Banwell and E.M.Mc Cash, "Fundamentals of Molecular Spectroscopy", Tata Mc Graw Hill, 4th edition (1994)
2. G.ArulDhas, "Molecular Structure and Spectroscopy", Prentice Hall of India Pvt. Ltd., New Delhi (2001)

References:

1. B.K.Sharma "Spectroscopy" 23rd Ed, Krishna Prakashan Media (P) Ltd (2013)
2. Gurdeep R. Chatwal and Sham K. Anand "Spectroscopy (atomic and molecular)" 5th Ed, Himalaya publishing house (2004)
3. B.P. Straughan and S.Walker, "Spectroscopy", John Wiley & sons(1997)

PSP 5402 High Energy Physics 5 hr / 4 cr

Preamble:

High energy physics is the study of subatomic elements of matter and radiation, and their interactions. It is an important branch of Physics that it enables a picture to be built up of what matter is and how it works. The tools of particle physics—complex accelerators, sensitive detectors, grid computing, high-volume data storage and analysis—are making a significant and lasting impact on quality of life for people around the globe.

Objectives:

1. To know the characteristics of strong and weak interactions and to familiarize the consequences of boson exchange.
2. To provide the students a solid background for research and development projects within high-energy physics instrumentation.

Unit 1: Preliminary notions

Energy and length scales in HEP, particle accelerators and detectors, Hadrons and Leptons, Strong and Weak Interactions, Isospin and strangeness, List of particle properties, conserved quantum numbers

Unit 2: Strong interactions

Hadronic resonances, SU(2) and SU(3) symmetries, Lie groups and Lie algebras, quarks, baryons and mesons as composites of quarks and antiquarks, discovery of "colour", Deep inelastic scattering and partons

Unit 3: Weak interactions

Fermi's theory, parity violation, current x current theory, Electroweak dynamics, Neutral Current, W and Z bosons, Higgs boson, Kzero-Kzerobar oscillations, CP violation, CKM matrix

Unit 4: Quantum Field Theory
QED as an example of QFT, Yang-Mills theory, Higgs mechanism and electroweak theory, asymptotic freedom and QCD, Standard model of HEP

Unit 5: Neutrinos
Solar, atmospheric, reactor and accelerator neutrinos, neutrino oscillations, Majorana neutrinos and neutrinoless double beta decay, India-based Neutrino Observatory

Text Book:
1. Donald H. Perkins ,"Introduction to High Energy Physics", Academic press (2000)

References:

1. Mark Thomson, "Modern Particle Physics", 1st Ed, Cambridge University Press (2013)
2. Brian Martin, "Particle Physics - A Beginner's Guide", Adams Media (2011)

PSP 5404 **Digital Electronics** **4 hr / 4 cr**

Preamble:
This course explains how networks of semiconductor devices such as transistors perform signal-processing tasks. The digital nature of electronic signals offers a convenient, compact and noise-free representation of information. Digital signals can be easily stored in an electronic memory and can be easily understood by digital microprocessors.

Objectives:
1. To study digital logic along with the basics of Digital Circuits and different types of memories.
2. To help the students learn about the use of digital electronics in DAC, ADC and logical IC families for designing digital circuit.

Unit 1: Filp –Flop and its Application
Flip-Flop - Timing Considerations ,Master/Slave Flip-Flops, Flip-Flop Applications , Flip-Flop Synchronization, Detecting an Input Sequence, Data Storage and Transfer, Serial Data Transfer: Shift Registers, Frequency Division and Counting ,Schmitt-Trigger Devices ,One-Shot (Monostable Multivibrator),Analyzing Sequential Circuits, Clock Generator Circuits, Troubleshooting Flip-Flop Circuits , Edge-Triggered Devices

Unit 2: Counter and its Design
Asynchronous Counters, Synchronous (Parallel) Counters, Synchronous Down and Up/Down Counters, Pre-settable Counters, Decoding a Counter , Decoding Glitches, Cascading BCD Counters, Synchronous Counter Design, LPM Counters, State Machines

Unit 3: DAC and ADC
Digital versus Analog, Digital-to-Analog Conversion, D/A-Converter Circuitry, DAC Specifications, an Integrated-Circuit DAC, DAC Applications, Troubleshooting DACs Analog-to-Digital Conversion, Digital-Ramp ADC, Data Acquisition, Successive-Approximation ADC, Flash ADCs, A/D Conversion Methods, Digital Voltmeter, Sample- and-Hold Circuits, Multiplexing

Unit 4: IC Logic families

Digital IC terminology, TTL logic family, TTL series characteristics, Improved TTL series, TTL loading and fan-out, other TTL characteristics, Connecting TTL outputs together, tristate TTL, ECL family, MOS digital ICs & Characteristics, CMOS logic & characteristics, Bilateral switch, TTL driving CMOS and vice-versa, Low voltage technology.

Unit 5: Semiconductor Memories, **Programmable Logic Devices**

RAM architecture, Static RAM, Dynamic RAM (DRAM), DRAM structure, and operation, DRAM Read/Write cycles, DRAM refreshing, Expansion of word size and capacity, Basic idea, PLD architecture (PROM), PAL, PLAs, Applications of a programmable Logic Device

Text Book:

1. Ronald J.Tocci, "Digital Systems-Principles and Applications" ,6thEd, PHI, New Delhi (1999)

References:

1. Herbert Taub and Donald Schilling, , "Digital Integrated Electronics" McGraw Hill(1985)
2. S.K. Bose, "Digital Systems" 2nd Ed, New Age International (P) Ltd (1992)
3. D.K. Anvekar and B.S. Sonde "Electronic Data Converters: Fundamentals & Applications" ,TMH, (1994)
4. A.P. Malvino and D.P. Leach, ,"Digital Principles and Applications" TMH (1991)

PSP 5406 Condensed Matter Physics – II 4 hr/4 cr

Preamble:

Condensed matter physics is a highly diverse area of research, ranging from innovative studies of the basic properties of novel materials, the study of complex fluids and nonlinear phenomena, to the development and study of nanometer-scale electronic, spintronic, superconducting and optical systems. It forms the basis for the exploration of new materials such as carbon nanotubes and semiconducting nanowires, as well as the basis for the next generation of electronic devices. Much of the modern technology that energizes today's society (e.g. electronics, magnetics, and photonics) is rooted in condensed matter physics.

Objectives:

1. To study the optical properties of solids, superconductivity and their applications.
2. To provide a foundation for the quantum theory of magnetism.

Unit 1: Optical properties of solids

Dielectric function of the electron gas-Plasmons, Polaritons and Polarons- Optical processes and excitons: Kramers-Kronig relations-Excitons

Unit 2: Superconductivity

Superconductivity- Meissner effect - London theory- BCS theory of superconductivity- Type I and Type II superconductors- DC and AC Josephson effects and their applications- High temperature superconductors, SQUID

Unit 3: Magnetism

Quantum theory of dia and para magnetism- Rare earth ions- Hund's rule- Orbital quenching- Paramagnetic susceptibility of conduction electrons- Ferromagnetic order- antiferromagnetic order- Magnons, thermal excitons, spin waves- Hall effect, quantum Hall effect – Fractional Hall effect

Unit 4: Dielectrics and Ferroelectrics

Macroscopic electric field- Local electric field at an atom- Dielectric constant and polarizability- Structural phase transitions – Landau phase transitions - Ferroelectric crystals

Unit 5: Defects and Dislocations

Point defects: Lattice vacancies- Diffusion- Color centers- Surface and interface physics: Surface crystallography- surface electronic structure- Magneto resistance in a two-dimensional channel- p-n junctions- Heterostructures- Semiconductor lasers- Light emitting diodes- Scanning tunneling microscopy- Dislocations: Shear strength of single crystals- Dislocations- Strength of alloys- Dislocations and crystal growth- Hardness of materials

Text Book:

1. Charles Kittel, 'Solid State Physics', 7th Ed, John Wiley and sons, (1996)

References:

1. H.V. Keer, 'Principles of Solid State'Wiley Eastern Ltd, (1994)
2. S.O.Pillai, 'Solid State Physics'Wiley Eastern Ltd, (1994)
3. A.C.Rose-innes and E.H.Rhodrick, 'Introduction to Superconductivity' Paramount Press, (1978)
4. S.V.Subramanian, E.S.Rajagopal, 'High Temperature Superconductivity'Wiley Eastern Ltd, (1989)
5. Azaroff and David Mermin, 'Solid State Physics'Sounders College, (1981)
5. W. F. Dejong "General Crytallography", W. H. Freman and company (1959)
6. M.A.Wahab, " Solid State Physics" Narosa Publishing House, Delhi (1999)

PSP 5310 Matrix & Fourier Optics 4 hr / 3 cr

Preamble:

This course examines the use of ray-transfer matrices for some topics in Fourier optics, exploiting the mathematical simplicity of ray matrices compared to diffraction integrals. A simple analysis of the physical meaning of the elements of the ray matrix provides a fast derivation of the conditions to obtain the optical Fourier transform. These matrix methods are particularly useful when a large number of elements are considered.

Objectives:

1. To introduce the students to the use of matrix methods in optics.
2. To enable the students to study Fourier techniques in optics.

Unit 1: Matrix methods in Optics

Paraxial Optics: Translation matrix and refraction matrix The ray-transfer matrices for a system –- Derivation of properties of a system from its matrix – Experimental determination of the matrix elements of an optical system.

Unit 2: Matrices in Polarization Optics

Stokes parameter – use of Muller calculation for transferring a stokes parameter – use of Jones calculus for transferring a Maxwell's column – Experimental determination of the elements of a Jones matrix.

Unit 3: Fourier Optics

Fourier analysis in two dimensions - Scalar Diffraction theory: The Rayleigh – Somerfield theory of diffraction by a plane screen – Approximation of Huygens – Fresnel principle – Examples of Fraunhofer diffractions patterns and of Fresnel. Fourier transforming and imaging properties of lenses

Unit 4: Frequency Analysis of Optical Imaging Systems

Frequency analysis of diffraction – limited coherent and incoherent imaging systems- Spatial Filtering and optical image processing - frequency domain synthesis – Vander Lugt filter – application of character recognition

Unit 5: Holography

The basic principle – Gabor hologram – The Leith Upatneieks hologram – Effects of film non linearity and emulsion thickness – Reflection holograms – Application: Microscopy – Interferometry – Vibration analysis – Character recognition.

Text Book(s):

1. Gerard A & Burch J.M "Introduction to Matrix Methods in Optics", John Wiley (1975)
2. Goodman J.W "Introduction to Fourier Optics", McGraw Hill, New York (1996)

References:

1. Gaskill J.D "Linear Systems, Fourier Transform and Optics", John Wiley (1975)
2. Ghatak. A.K & Thyagarajan.K. "Optical ElectronicsCambridge University Press, Cambridge "(1989)
3. Pedrotti F.L and Pedrotti L.S. "Introduction to Optics", Pretice hall in Inc. (1987)
4. Grant R. Fowles "Introduction to Modern Optics", Holt, Rinehart &Winson, Inc. (1975)
5. Nussbaum A & Philips R.A. "Contemporary Optics for Scientists and Engineers", Prentice Hall, New Delhi, (1976)

PSP 5312 **Laser and Non Linear Optics** **4 hr / 3 cr**

Preamble:

Lasers produce highly monochromatic beams, which can be concentrated to extremely high intensities. Non-linear optics is an extensive field theory. The key that opened the door to Non-linear optics was the availability of high-power lasers of hundreds of varieties. A peculiar property of the laser beam, essential to non-linear optics, is its high degree of coherence, because the stimulated emissions of different radiating atoms are synchronized.

Objectives:

1. To deal with the basic physics behind laser operation, different laser systems and their applications like interaction with matter and information processing
2. To study Non-linear techniques in optics

Unit 1: Laser Theory

Einstein Coefficients – Light amplification – threshold condition – rate equations – three level systems – four level systems - variation of laser power around threshold – optimum output coupling – line broadening mechanisms – Q factor

Unit 2: Laser Modes

Modes of a rectangular cavity and the open planar resonator – The ultimate line width of a laser – mode selection – Transverse and longitudinal Q – Switching -mode locking – modes of a confocal resonator system

Unit 3: Laser Types and Applications

Types of Laser: Gas laser – solid state laser – semiconductor laser – dye lasers – excimer lasers. Applications of lasers: Lasers and interaction – lasers and information

Unit 4: Crystal Optics and Electro Optic Effect

Plane wave in anisotropic media – wave refractive index – ray refractive index – The index ellipsoid - Fresnel's equation of wave normal - The electro optic effect in KDP, lithium niobate and lithium tantalite crystals – The index ellipsoid in the presence of external electric field

Unit 5: Acousto and Non – Linear Optic Effect

Raman-Nath diffraction – Theory of Raman – Nath diffraction – Bragg diffraction – Raman – Nath - acousto optic modulator – Bragg modulator- self – focussing phenomenon – Second harmonic generation - non linear phenomena

Text Book(s):

1. Thyagarajan.K & Ghatak.A.K. "Lasers: Theory and Applications, Plenum Publishing Corporation, New York, (1981)
2. Ghatak.A.K & Thyagarajan.K. "Optical Electronics", Cambridge University Press, Cambridge (1989)

References:

1. Milonni.P.W & Ederly J.H. Lasers, John Wiley & Sons, (1988)
2. Gaskill J.D Linear Systems, Fourier Transforms and Optics, John Wiley, (1975)
3. Pedrotti F.L and Pedrotti L.S. Introduction to optics, Pretice Hall Int. Inc, (1987)
4. Grant R. Fowles Introduction to Modern Optics, Holt, Rinehart & Winston, Inc, (1975)

PSP 5414	**Astrophysics**	**4 hr / 4 cr**

Preamble:

This course covers the physical properties of heavenly bodies and their behaviour. The interactions between these celestial bodies are studied in detail as well. Studying astrophysics provides students with ample opportunities in the arenas of astronomy, space research and other pertaining fields.

Objectives:

1. To impart a deep understanding of typical topics in Astronomy by presenting them in an active program.
2. To provide students with the background and training in Research Methods and Skills related to Astronomy.

Unit 1: Positional Astronomy

Development of Astronomy and Birth of Modern Astronomy – Physics of Kepler and Newton – Seasons – Time and Precession – Constellation and nomenclature of stars – Stellar distance – Stellar magnitude – Spectral Classification – Colour index – Aberration and Parallax.

Unit 2: Astronomical Observations

Optical telescopes – Types of telescopes – Reflector and refractor type - Recording devices – Photography , Photomultipliers and CCDs. Radio telescope – Interferometers, T, Y and Cross interferometers. Techniques of observation in IR, UV, X – Ray and Gamma ray regions.

Unit 3: Sun and Stellar Bodies

Sun as a star – layers of Sun – Photosphere – Chromosphere – Corona – phenomenon of Sun – sun spots – Prominences – solar flares – eclipses – limb darkening – Galaxy – Types of Galaxies – Milky way galaxy – Comets- Asteroids and meteoroids.

Unit 4: Stellar Structure and Evolution:

Basics equations of stellar structure – Nuclear energy sources – Jean's criterion - Star formation – H-R diagram – Main sequence stars – end state of stars – Chandrasekar mass limit – white dwarfs – Novae and Super novae – Pulsars – Neutron star – Black hole – Binaries and Variable stars.

Unit 5: Cosmology

Hubble's law – Models of Universe – The Big-Bang – Steady State theory – consequences of general theory of relativity – Bending of light – Background radiation – Future of the Universe.

Text Book(s):

1. George o. Abell, 'Exploration of the Universe', Saunders College Publishing, (1986)
2. Frank H. Shu, The Physical Universe, An introduction to Astronomy, University Science Books, Mill Valley, California, (1982)
3. R.Alder, M.Bazrin and M.Schiffer, 'Introduction to General theory of Relativity', Mc Graw Hill Publications, (1975)

References:

1. K.D.Abhyankar, Astrophysics – Stars and Galaxies, Tata McGraw Hill Publications, (1989)
2. William Kaufmann Astronomy: The Structure of the Universe, McMillan Publishing Co.inc, New York (1999)

THE AMERICAN COLLEGE POST GRADUATE DEPARTMENT OF PHYSICS
Programme for M. Sc. PHYSICS (w. e. f. 2018-19 onwards)

Semester	Course No.	Course Title	Hours/ Wk	Credits	Marks

I	PGP / PSP 4431	Classical & Non Linear Dynamics	5	4	80
	PGP / PSP 4433	Mathematical Physics – I	4	4	80
	PGP / PSP 4435	Condensed Matter Physics – I	4	4	80
	PGP / PSP / PSP 4337	Astrophysics	4	3	60
	PGP / PSP 4339Observational Astronomy PGP / PSP 4341Physics of Home Appliances*		4	3	60
	PGP / PSP 4343	Physics Lab – I	9	3	60
			30	**21**	**420**
II	PGP / PSP 4434	Instrumentation & Microcontrollers	5	4	80
	PGP / PSP 4436	Mathematical Physics – II	4	4	80
	PGP / PSP 4438	Quantum Mechanics – I	4	4	80
	PGP / PSP 4340	Nanophysics	4	3	60
	PGP / PSP 4342Physics in Human Physiology PGP / PSP 4344Sustainable Energy Resources*		4	3	60
	PGP / PSP 4346	Physics Lab – II	9	3	60
			30	**21**	**420**
III	PGP / PSP 5431	Nuclear & Particle Physics	5	4	80
	PGP / PSP 5433	Electrodynamics & Plasma Physics	4	4	80
	PGP / PSP 5435	Physical Electronics	4	4	80
	PGP / PSP 5437	Laser & Spectroscopy	4	4	80
	PGP / PSP 5439	Quantum Mechanics – II	4	4	80
	PGP / PSP 5441	Project – I	9	4	80
			30	**24**	**480**
IV	PGP / PSP 5432	Thin Films &Vacuum Technology	5	4	80
	PGP / PSP 5434	Condensed Matter Physics – II	4	4	80
	PGP / PSP 5436	Analog Electronics	4	4	80
	PGP / PSP 5438	Thermodynamics & Statistical Physics	4	4	80
	PGP / PSP 5440	Matrix, Fourier & Non Linear Optics	4	4	80
	PGP / PSP 5442	Project – II	9	4	80
			30	**24**	**480**

* Buffer Course

PGP / PSP / PSP 4431 **Classical and Non-Linear Dynamics** **5 hours/4Cr**

This course enables learners to understand the

Basic concepts and application of Lagrangian dynamics.
Theory of small oscillations and central force problem.
Dynamics of rigid bodies and physics associated with it.
Usage of Hamiltonian equations and Canonical Transformations.
Basics of non-Linear Dynamics.

Unit I: Lagrangian Dynamics

Constraints - D' Alembert's Principle and Lagrange's Equations - Velocity-Dependent Potentials and the Dissipation Function - Hamilton's Principle - Some Techniques of the Calculus of Variations - Derivation of Lagrange's Equations from Hamilton's Principle - Conservation Theorems and Symmetry Properties - Energy Function and the Conservation of Energy.

Unit II: Central Force Problem and Small Oscillations

Reduction to the Equivalent One-Body Problem - The Equations of Motion and First Integrals Scattering in a Central Force Field - Transformation of the Scattering Problem to Laboratory Coordinates-Small Oscillations - The Eigenvalue Equation and the Principal Axis Transformation - Frequencies of Free Vibration, and Normal Coordinates, Linear Tri atomic Molecule.

Unit III: Rigid body Dynamics

The Independent coordinates of a Rigid Body - Orthogonal Transformations - The Euler Angles - Angular Momentum and Kinetic Energy of Motion about a Point – Tensors - the Inertia Tensor and the Moment of Inertia - The Eigen values of the Inertia Tensor and the Principal Axis Transformation - Solving Rigid Body Problems and the Euler Equations of Motion.

Unit IV: Hamiltonian dynamics and Canonical Transformations

Legendre Transformations and the Hamilton Equations of Motion - Cyclic Coordinates and Conservation Theorems - Equations of Canonical Transformation - Examples of Canonical Transformations - The Harmonic Oscillator - The Symplectic Approach to Canonical Transformations - Poisson Brackets and Other Canonical Invariants - The Angular Momentum Poisson Bracket Relations.

Unit V: Nonlinear dynamics

Autonomous and non - autonomous systems – Differential equation: equilibrium points-Phase space and Phase trajectories - Stability, Attractors and Repellers - General criteria for stability – Classification of Equilibrium Points - Periodic Attractor - Some simple bifurcations - Saddle-Node, Pitchfork, Transcritical and Hopf.

Text Books:

Goldstein, Poole and Safko, *Classical Mechanics*, 3 edition, Pearson Publication (2001)
Unit I: Chapter 1.3-1.5, 2.1-2.3, 2.6-2.7
Unit II: Chapter 3.1-3.2, 3.10-3.11, 6.1-6.4
Unit III: Chapter 4.1-4.4, 5.1-5.5
Unit IV: Chapter 8.1-8.2, 9.1-9.5, 9.7
M. Lakshmanan and S. Rajasekar, Nonlinear *Dynamics*, Springer (India) Pvt. Ltd. (2003)
Unit V: Chapter 3.1-3.5, 4.1.

References:

John R. Taylor, *Classical Mechanics*, University Science Books, (2004)
Louis N. Hand and Janet D. Finch, *Analytical mechanics*, Cambridge University Press, (1998)
J.C. Upadyaya, *Classical Mechanics*, Himalayan Publishing House, New Delhi (2009)

PGP / PSP 4433 **Mathematical Physics - I** **4 hrs / 4 Cr**

This course enables learners

- To earn knowledge in complex variables
- To acquire knowledge about special functions and series solutions of differential equations in physics
- To understand basic concept about Fourier series and integral transforms
- To know the basis about numerical methods
- To impart mathematical knowledge for the description of physics phenomena

Unit I: Complex Variable

Functions of a complex variable – analytic function – Cauchy-Riemann conditions - Cauchy's integral theorem and integral formula - Taylor's and Laurent's expansions - Cauchy residue theorem – Evaluation of residues - Evaluation of definite integrals

Unit II: Special Functions in Physics

Gamma functions – Beta functions – Dirac-Delta functions – Green's functions- One dimension – Two and three dimension - Applications of Green's functions.

Unit III: Series Solutions of Differential Equations in Physics

Differential equations, Generating function, Rodrigues' formula Recurrence relations and Orthogonality of Bessel, Legendre, Hermite and Laguerre polynomials

Unit IV: Fourier series and Integral Transforms

Fourier series - Application of Fourier series - Fourier Integral theorem - Fourier Transform – Convolution theorem – Parseval's relation – Transforms of derivatives - Application of Fourier transform - Laplace transform - Application of Laplace transform.

Unit V: Numerical Methods

Roots of polynomial and transcendental equations - Newton-Raphson method - Lagrange's interpolation - Numerical integration - Trapezoidal, Simpson's method - Euler's method, Runge-Kutta method

Text Books:

Charlie Harper, *Introduction to Mathematical Physics*, Prentice-Hall, Inc, (2008)
Unit I: Chapter 3.3, 3.4, 4.2 – 4.7
Unit IV: Chapter 7.1, 8.1 – 8.3

George B. Arfken and Hans J. Weber, *Mathematical Methods for Physicists*, Elsevier Academic Press Seventh Edition, (2012)
Unit II: Chapter10.1, 4, 5; 8.6; 16.5,6
Unit III: Chapter11.1, 2; 12.1, 2, 3; 13.1,2

M.K. Venkataraman, *Numerical Methods in Science and Engineering*, National Publishing Co, Fifth Edition, (1999)
Unit V: Chapter 3.1 – 3.5; 8.4; 9.7, 8, 10; 11.10,13

References:

Eugene Butkov, *Mathematical Physics*, Addison Wesley Publishing Company (1995).

Louis A. Pipes and Lawrence R. Harvill, *Applied Mathematics for Engineers and Physicists*, McGraw-Hill, International Third Edition (1970).

Sadri Hassani, *Mathematical Physics. A Modern Introduction to its Foundations*, Springer Second Edition (2002).

Mary L Boas, *Mathematical Methods in the Physical Sciences*, John Wiley & Sons Third Edition (2005).

P.K.Chattopadhyay, *Mathematical Physics*, New Age International Publishers (2013).

PGP / PSP 4438 **Condensed Matter Physics – I** **4 hrs / 4 Cr**

This course enables learners

- to acquire knowledge of crystal structure
- to understand the various diffraction techniques
- to develop the skill of finding the imperfection in crystals
- to appreciate the different bonding natures in crystals
- to apply the systematic approach to problem solving in crystal vibrations

Unit I: Crystallography

Basic concepts of crystallography-Index system for crystal planes –Simple crystal structure – Reciprocal lattice vectors – Fourier analysis of the basis: Structure factor for SC, BCC, FCC structures – Atomic scattering factor- Quasi crystals.

Unit II: Crystal diffraction

Braggs law – different scattering methods-derivation of scattered wave amplitude - anomalous dispersion of scattering by crystals- Theory of X-ray diffraction-temperature effect- crystal structure determination

Unit III: Crystal imperfections

Imperfections in crystals –Point defects: Lattice vacancies- Diffusion- Color centers- Surface and interface physics: Concentration of Frenkel and Schottky defects – Line imperfections – Screw imperfection – Burger vector – Surface imperfections – volume defects-Dislocations.

Unit IV: Crystal binding

Crystals of inert gas – van der Walls interactions – Repulsive interaction – Equilibrium lattice constants – Cohesive energy – Ionic crystals – Madelung energy – Evaluation of Madelung constant – Covalent, Metallic and Hydrogen bonding – elastic strain components

Unit V: Crystal vibrations

Vibrations of crystal with monoatomic basis – group velocity – Two atoms per basis – Quantization of elastic waves – Phonon momentum – Phonon heat capacity – Debye theory of specific heat – Debye T^3 law – Anharmonic crystal interactions

Text Book:

Charles Kittel, *Introduction to Solid State Physics*, 5th edition,
(1993). Unit I: Pages: 18- 30, Pages: 50 – 62
Unit II: Pages: 37- 48,
Unit III: Pages: 538-549,565-581
Unit IV: Pages: 76-100,
Unit V: Pages: 107 – 119,127-142

References:

S.O. Pillai, *Solid State physics*, New age international (P) limited (1997).
Ali Omar, *Elementary Solid State Physics*, Pearson Education India, (2000).
H.V Keer, *Principles of Solid State*, Wiley Eastern Lmt. (1994)
M.A.Wahab, *Solid State Physics*, Narosa Publishing house, Delhi, (1999)

PGP / PSP 4339 **Observational Astronomy** **4 hrs / 3 Cr**

This course enables learners

- To understand the advances in astronomy from ancient time
- To understand the birth and evolution of star
- To earn knowledge in understanding galaxy
- To gain knowledge about different types of telescopes
- To know the basis of the origin of universe

Unit I: Birth of Modern Astronomy

Birth of modern astronomy- –Compare and contrast the views of reality held by Plato and Aristotle– universe in the seventeenth century – Kepler's Laws – Newtonian gravitation – seasons – Eclipse – Solar, lunar - solar family.

Unit II: Stellar Evolution

Formation of a star from a cloud of interstellar matter- Birth of low mass stars like our sun, -main-sequence star to a dead star- white dwarf - neutron star - Inventory of the Solar System

Unit III Galactic astronomy:

Milky Way - Hubble classification of galaxies-Spiral galaxies, Elliptical galaxies,Irregular galaxies, Dwarf galaxies – Mysterious objects – Pulsar, Quasar, comets, asteroids - meteors and meteoroids.

Unit IV: Telescopes

Astronomical observations – optical telescopes – Reflecting – refracting – telescope mount – – Radio telescope — UV-IR-X-ray telescopes.

Unit V: Origin of Universe

The Big bang - Formation of Elements, Discovery of the Galaxies, Expansion of the Universe – Hubble's law – steady state – pulsating theory

Text books:

Nigel Marshall, *GCSE Astronomy*, IV Edition , Mickledore Publishing, (2010)
Unit I:Chapter 1.4
Unit II:Chapter 3.4, 2.1
Unit III: Chapter 4.1, 4.2,
2.2 Unit V:Chapter 4.3

William J. Kaufmann, *Astronomy: The Structure of the Universe*, Macmillan Publishers Co., Inc. New York, (1999)
Unit I: Chapter 1
Unit IV:Chapter 6
Unit V: Chapter 14

References:

Shu F, *The physical universe*, University of California, (1982).

George O.Abell, *Exploration of the Universe*, Saunders college publishing, (1986)

K.D.Abhayanker, *Astro Physics Stars and Galaxies*, Tata McGraw – Hill publishing, New Delhi (1992)

PGP / PSP 4341 **Physics of Home Appliances** **4 hrs / 3 Cr**

This course enables learners

To acquire knowledge about principles of operation of everyday home appliances

To learn techniques of working of various domestic appliances

To acquire skills testing and maintenance of domestic appliances

To create an awareness towards consumption of energy

To contribute towards a greener environment

Unit I: Introduction to Electricity and Electronics

Basic Electricity: Voltage, Current, Resistance, Impedance & Power factor -Transformers - Step-up & Step-down - Single phase & Three phase circuits – Fuse, Concept of Earthing

Electronics: Familiarization of electronic components - Capacitor, Choke coil, Diode, Transistor, Thyristor

Basic Equipments for testing and servicing: Multimeter - Measurement of current, voltage and resistance - Checking transistors and diodes in circuit measurements - Soldering Iron - Flux - Lead

Unit II: Heating Appliances

Electric stove - Electric Rice cooker - Toaster - Kettle - Coffee maker -Iron box -Immersion heater - Geyser - Hair drier- Microwave oven

Unit III: Motorised Appliances

Electric fans - Mixer - Grinder/Blenders -Washingmachine - Vacuum cleaner - Domestic water pump - Dish washer

Unit IV: Refrigeration Appliances

Refrigerator: Compressor - coolants - Automatic defrost circuits - Air coolers - Air conditioners

Unit V: Other Appliances

Lights: Incandescent Bulbs, Tubelight, CFL bulb – LED- Voltagestabilizer - Inverters – UPS

References

Eric Kleinert, *Troubleshooting and Repairing major appliances*, McGraw Hill Professional, 3rd edition, (2012)

B.L. Theraja& A.K. Theraja, *A Text Book of Electrical Technology*, S. Chand & Company Ltd., New Delhi, India, (2005)

ShashiBhushanSinha, *Handbook of Repair and Maintenance Of Domestic Electronics Appliances*, BPB Publications, India, (2016)

PGP / PSP 4343 **Physics Lab - I** **9 hrs / 3 Cr**

The laboratory sessions are designed to

- Inculcate good laboratory practice and work habits.
- Reinforce the concepts and techniques presented in the lectures.
- Make students acquainted with Data and error analysis
- Offer hands-on experience with moderninstrumentation.
- Teach soft skillsto the students.

Total of 16 Experiments:

Compulsory experiments:

- Fabrication of a dual power supply –regulation study
- Familiarization of CRO, signal generators
- Work shop practice – Use of tools and machines.

Any 7 from the following:

- Familiarization - excel – calculations and graph and PCB software
- CDS calibration – Na Lamp – Hg spectrum – Fabry perot etalon.
- Michelson interferometer – Wavelength –Na, Hg & laser.
- Reflection grating – finding groove spacing- CD, DVD and grating.
- Calibration techniques - Thermister - Thermocouple
- linear polarizer & Quarter wave plate - circular and elliptical polarization
- Eddy current – Electromagnet & mapping the magnetic field.
- Refractive index of glass, and liquids, sugar content– laser pointer.
- Fourier series - analyzing periodic function - experiment
- Balmer series - hydrogen spectrum – Rydberg constant
- Hartman interpolation formulae – CDS
- Age of universe - using spectrum and galaxy diagram
- Channelled spectrum – to determine the thickness of mica sheet

Any 6 from the following:

- Characteristics of a solar cell- fill factor.
- Band Energy gap using diode and LED
- Study of ac circuits – RC, RL, and LCR – using CRO.

Use of Digital and Analog Simulation software for solving circuits.
Lab View – Data logging
Study of charging and discharging of a capacitor.
OP-AMP - wave form generator- sine-square-triangle-ramp
second order active filter - OP-AMP
Timer 555 – a stable, mono stable, bi stable, VCO and Schmidt trigger.
Multiplexing and demultiplexing - 4- bit

PGP / PSP 4436 **Mathematical Physics - II** **4 hrs / 4 Cr**

This course enables learners

To understand about the linear vector and matrices
To know the basic about Tensors
To earn knowledge about Tensor calculus and probability
To acquire knowledge about group theory and its representation
To emphasize the use of advanced mathematical tools to analyse physics phenomenon

Unit I: Linear Vector Space and Matrix Analysis

Definition of a linear vector space – Linear independence, basis – Scalar product – Orthonormal basis – Gram-Schmidt orthogonalization process – Linear operators. Special matrices – Eigen values and Eigen vectors – Cayley Hamilton theorem – Coordinate transformations.

Unit II: Tensors Analysis

Introduction – Transformation of Coordinates – Contravariant and Covariant tensors - Algebra of tensors – Quotient law – The line element – Fundamental metric tensor – Associate tensors.

Unit III: Tensors Calculus and Probability

Christoffel symbols – Covariant differentiation of tensors – Equation of the Geodesic line – Riemann-Christoffel tensors. Elementary probability theorem – random variables – Binomial, Poisson and Normal distributions

Unit IV: Abstract Group Theory

Definition and nomenclature – multiplication table – Rearrangement theorem – Cycle groups – Sub-groups – Cosets, class – Normal divisors and factor groups – Class multiplication - Continuous groups – SU (2) and SU(3) – Orthogonal.

Unit V: Theory of Group Representation

Reducible and irreducible representation – Great orthogononality theorem (no proof) – Character representation – Character table decomposition of reducible representation – Regular representation – Application of representation theory

Text Books:

P.K.Chattopadhyay, *Mathematical Physics*, New Age International Publishers (2013).
Unit I: Chapter 7.1–7.6

Charlie Harper, *Introduction to Mathematical Physics*, Prentice-Hall, Inc (1976),
Unit I: Chapters 2.6 – 2.9
Unit II: Chapters 9.1 – 9.5
Unit III: Chapter 9.6

Louis A. Pipes and Lawrence R. Harvill,*Applied Mathematics for Engineers and Physicists*, McGraw-Hill, International Third Edition (1970)
Unit III: Chapter 16.6 – 16.13

A.W.Joshi, *Elements of group theory for physicists*, New Age International Publishers (1997),
Unit IV: Chapter 1, 4.5.4.6, 4.8
Unit V: Chapter 3

References:

Eugene Butkov, *Mathematical Physics*, Addison Wesley Publishing Company (1995).

A.W.Joshi, *Matrices and Tensors in Physics*. New Age International Publishers (2017).

George B. Arfken, Hans J. Weber and Frank E. Harris, *Mathematical Methods for Physicists*, Elsevier Academic Press Seventh Edition (2012).

Sadri Hassani, *Mathematical Physics. A Modern Introduction to its Foundations*, Springer Second Edition (2002).

Mary L Boas, *Mathematical Methods in the Physical Sciences*, John Wiley & Sons Third Edition (2005).

SathyaPrakash, *Mathematical Physics*, Sultan Chand and Sons (2014).

PGP / PSP 4438 **Quantum Mechanics - I** **4 hrs / 4 Cr**

This course enables learners

To understand the significance of Schrodinger equation
To understand the basic concepts of wave mechanics
To develop skills in solving problems
To inculcate the knowledge of angular momentum and its applications
To acquire knowledge about scattering theory

Unit I: The Schrodinger Equation and Stationary States

A Free particle in One Dimension – Generalization to Three Dimensions – The Operator Correspondence and the Schrodinger Equation for a Particle Subject to Forces –

Normalization and Probability Interpretation – Non- normalizable Wave Functions and Box Normalization – Conservation of Probability – Expectation Values: Ehrenfest's Theorem – Admissibility Conditions on the Wave Function – A Particle in a Square Well Potential – Square Potential Barrier – Delta-Function Well

Unit II: General Formalism of Wave Mechanics

The Fundamental Postulates of Wave Mechanics – The Eigenvalue Problem: Degeneracy – Observables: Completeness and Normalization of Eigen functions – Closure – Physical Interpretation of Eigen values, Eigen functions and Expansion Coefficients – The Uncertainty Principle – States with Minimum Value for Uncertainty Product – Commuting Observables: Removable Degeneracy.

Unit III: Exactly Solvable Eigenvalue Problems

The Simple Harmonic Oscillator – Analytical Method – The Abstract Operator Method – Angular Momentum and Parity – Eigenvalue Equation for L^2: Eigen values and Eigen functions – Spherical Harmonics – The Hydrogen Atom – Solutions of the Radial Equation: Energy levels – Stationary State Wave functions - Charged particle in a uniform magnetic field – Integer Quantum Hall Effect.

Unit IV: Angular Momentum

The Hilbert Space of State Vectors: Dirac notation – Representation of Dynamical Operators – Unitary Transformation - The Eigenvalue Spectrum – Matrix representation – Spin Angular Momentum – A Charged particle in a uniform magnetic field - Non-relativistic Hamiltonian with Spin : Diamagnetism – Addition of Angular momenta – Evaluation of C. G. Coefficients - Spin Wave functions for a system of two spin-1/2 particles - Identical Particles with Spin.

Unit V: Scattering Theory

Kinematics of the Scattering Process – Wave Mechanical Picture of Scattering – Green's functions: Formal Expression for Scattering Amplitude – The Born Approximation; Partial Wave Analysis – Phase Shifts – The Scattering Amplitude in terms of Phase shifts – The Differential and Total Cross-Section: Optical Theorem – Phase shifts: Relation to Potentials – – Scattering by a Square Well, Hard Sphere;

Text Book:

P. M. Mathews & K. Venkatesan, *A Text Book of Quantum Mechanics*, 2^{nd} Ed., Tata McGraw Hill, New Delhi (2013)

Unit I: 2.1 – 2.14

Unit II: 3.2 – 3.5, 3.7 – 3.9, 3.11 - 3.13

Unit III: 4.1 – 4.4; 4.6 – 4.11; 4.15 – 4.17; 4.23 – 4.24

Unit IV: 7.1 – 7.3; 8.1 – 8.8

Unit V: 6.1 – 6.6; 6.8 – 6.12; 6.14 – 6.15; 6.17

References:

1. L. I. Schiff, *Quantum Mechanics*, 3^{rd} Ed., McGraw Hill New York (1968).

G. Aruldhas, *Quantum Mechanics*, 2^{nd} Ed., PHI Learning Private limited, New Delhi (2013).

J. J. Sakurai, *Modern Quantum Mechanics*, Addition-Wisley (1999).

S. R. Shankar, *Principles of Quantum Mechanics,* 2^{nd} Ed., Springer (2007).

PGP / PSP 4342 **Physics in Human Physiology** **4 hrs / 3 Cr**

This course enables learners to understand the
- Musculoskeletal system
- Circulatory system
- Nervous system
- Auditory system and
- Metabolic processes of Human body

Unit I: Forces and human body

Equilibrium and Stability - Equilibrium Considerations for the Human Body - Stability of the Human Body under the Action of an External Force - Skeletal Muscles - Levers - The Elbow The Hip - The Back - Standing Tip-Toe on One Foot - Dynamic Aspects of Posture. Standing at an Incline - Friction at the Hip Joint - Spine Fin of a Catfish

Unit II: Motions and human body

Vertical Jump - Effect of Gravity on the Vertical Jump- Running High Jump - Range of a Projectile - Standing Broad Jump - Long Jump- Motion through Air - Energy Consumed in Physical Activity.

Forces on a Curved Path - A Runner on a Curved Track - Pendulum - Walking - Physical Pendulum - Speed of Walking and Running - Energy Expended in Running - Alternate Perspectives on Walking and Running - Carrying Loads.

Unit III: Motion of Fluids and human body

Force and Pressure in a Fluid - Pascal’s Principle - Hydrostatic Skeleton - Archimedes’ Principle - Power Required to Remain Afloat - Buoyancy of Fish - Surface Tension - Soil - Insect Locomotion on Water - Contraction of Muscles – Surfactants.

Viscosity and Poiseuille’s Law - Turbulent Flow - Circulation of the Blood - Blood Pressure - Control of Blood Flow - Energetics of Blood Flow - Turbulence in the Blood - Arteriosclerosis and Blood Flow - Power Produced by the Heart - Measurement of Blood Pressure.

Unit IV: Sound / Heat and human body

Energy Requirements of People - Energy from Food - Regulation of Body Temperature - Control of Skin Temperature - Convection - Radiation - Radiative Heating by the Sun - Evaporation - Resistance to Cold - Heat and Soil**.**

Properties of Sound - Hearing and the Ear - Bats and Echoes - Sounds Produced by Animals - Acoustic Traps - Clinical Uses of Sound - Ultrasonic Waves

Unit V: Optics/Electricity and human body

Vision - Nature of Light - Structure of the Eye - Accommodation - Eye and the Camera - Lens System of the Eye - Reduced Eye - Retina - Resolving Power of the Eye - Threshold of Vision Vision and the Nervous System - Defects in Vision - Lens for Myopia - Lens for Presbyopia and Hyperopia - Extension of Vision.
The Nervous System- Electricity in the Bone- Electric Fish

Text book:

Paul Davidovits, *Physics in Biology and Medicine*, 3rd Edition, Academic press (2008).
Unit I : Chapter 1 and 2
Unit II : Chapter 3 and 4
Unit III: Chapter 7 and 8
Unit IV: Chapter 11 and 12
Unit V : Chapter 13 and 15

Reference book:

1. Vasantha Pattabhi and N. Gautham, *Biophysics*, Kluwer academic publishers, (2002).

PGP / PSP 4344 **Sustainable Energy Resources** **4 hrs / 3 Cr**

This course enables learners

To know the distinguished characteristics of renewable energy.
To understand the significance of solar radiation, which is an input to the solar devices
To explain the energy extraction from wind, tides and organic substances.
To observe the thermal energy conversions in ocean and earth's core.
To interpret different forms of energy storage and their transmission.

Unit I: Principles of Renewable Energy

Fundamentals - Scientific principles of renewable energy - Technical implications - Social implications - Heat transfer - Heat circuit analysis and terminology - Conduction - Convection - Radiative heat transfer - Properties of transparent materials - Heat transfer by mass transport.

Unit II: Solar Energy Systems

Solar radiation - Measurements of solar radiation- Solar water heating - Evacuated collectors Solar ponds - Solar concentrators - Solar thermal electric power systems - Photovoltaic generation - Solar radiation absorption - Types of photovoltaic systems and their Applications

Unit III: Energy Conversion Systems

Power from the wind - Turbine types and terms - Characteristics of the wind - Power extraction by a turbine - Electricity generation - Mechanical power - Biomass and biofuels - Biofuel classification - Biomass production for energy farming - Direct combustion for heat Pyrolysis (destructive distillation) - Anaerobic digestion for biogas - Vegetable oils and biodiesel - Tidal power - The cause of tides - Tidal current/stream power - Tidal range power.

Unit IV: Thermal Energy Systems

Ocean thermal energy conversion (OTEC) - Principles - Heat exchangers - Pumping requirements - Environmental impact - Geothermal energy - Geophysics - Dry rock and hot aquifer analysis - Harnessing Geothermal Resources.

Unit V: Energy Storage Systems

Energy systems, storage and transmission - The importance of energy storage and distribution Biological storage - Chemical storage - Heat storage - Electrical storage: batteries and accumulators - Fuel cells - Mechanical storage.

Text Book:

John Twidell and Tony Weir, *Renewable Energy Resources*, 2nd edition, London, Taylor & Francis Group, (2006).

Unit I: Chapter: 1.3 - 1.6, 3.1 - 3.7
Unit II: 4.1, 4.7, 4.8, 5.1, 5.7, 6.7 – 6.9, 7.1, 7.3, 7.4, 7.6 – 7.9
Unit III: 9.1, 9.2, 9.6 – 9.9, 11.1 – 11.5, 11.8, 11.10, 13.1, 13.2, 13.4, 13.5
Unit IV: 14.1, 14.2 - 14.4, 14.6, 15.1 – 15.4
Unit V: 16.1 – 16.7

References:

D. Y. Goswami, F. Kreith and J. F. Kreider, *Principles of Solar Engineering*, Philadelphia, Taylor and Francis, (2000).

L.L. Freris, *Wind Energy Conversion Systems*, Prentice Hall, (1990).

C. S. Solanki, *Solar Photovoltaics: Fundamental Applications and Technologies,* Prentice Hall of India, (2009)

S.P. Sukhatme, *Solar Energy: principles of Thermal Collection and Storage*, Tata McGraw-Hill (1984).

E H Thorndike, *Energy & Environment: A Primer for Scientists and Engineers,* Addison-Wesley Publishing Company, (1976)

R Wilson & W J Jones, *Energy, Ecology and the Environment*, Academic Press Inc. (1975)

PGP / PSP 4346 **Physics Lab - II** **9 hrs / 3 Cr**

The laboratory sessions are designed to

- Inculcate good laboratory practice and work habits.
- Reinforce the concepts and techniques presented in the lectures.
- Make students acquainted with Data and error analysis
- Offer hands-on experience with modern instrumentation.
- Teach soft skills to the students.

Total of 16 Experiments: **Any 8 from the following:**

- Hall Effect - Hall coefficient, Hall voltage, carrier density and mobility.
- GM counter - counter plateau and resolving time
- CDS - arc spectrum
- Michelson interferometer - optical bread board - refractive index of gas
- Ultrasonic interferometer - Physical parameters of pure and binary liquids - dielectric constant, verification of iterative equations
- XRD – Determination of structural parameters
- Determination of Hysteresis loss – tracing B-H loop on the CRO
- Free fall – displacement-time graph, g calculation using charging and discharging
- Four probe - Measurement of sheet resistance, resistivity, Energy gap -thin films, silicon & aluminum foil.
- Susceptibility - electro magnet - Quinke's method – liquid
- Microwave - Characteristics, dielectric constant in liquid and solids
- Thick lens systems – nodal points – optical bench
- Charge of the electron - using spectrometer.
- MATH-CAD – Graphics and Mathematical analysis

Any 8 from the following:

- Pulse Width Modulation - Study & DC motor control.
- Op-Amp - logarithmic and Anti logarithmic amplifier, current to voltage converters and voltage to current converters
- FM Modulation and demodulation.
- Experiments in physics with expEYE-17.
- Lab view – multiplexer and demultiplexer
- Stepper motor control - using micro controller.
- Design of counters – using flip flops, MOD counters using 7490.
- FET – characteristics – Vp, I_{DSS}, gm, rd.
- Analog computation using - OP-AMP.
- D/A conversion - (R-2R and weight network).
- Instrumentation amplifier.
- Study of RAM – using ICs.

Value Added Courses

w.e.f. 2020-2021

Semester	Course Code	Course Title	Hrs./Wk.	Credits
I	PGP421V	Electronic Workbook for Physics	2	2
II	PGP422V	X-ray Diffraction Techniques for Material Characterization	2	2
III	PGP521V	PYTHON for Physicists	2	2
IV	PGP522V	Practical Astronomy	2	2

PGP421V *Electronic Workbook for Physics* *2Hrs./ 2Cr.*

This Course offers professional guidance to customize electronic worksheets to solve Physics problems. It also strengthens their problem solving, analyzing and synthesizing skills for Physics Problems.

At the end of the course, students will be able to

i. create and edit customized electronic worksheets.
ii. solve vector, matrix equations and use built-in functions.
iii. analyze physics problems using differential equations and optimization techniques.
iv. present and synthesize results in the graphical form.
v. analyze and synthesize using gallery of graphs.

Unit 1Create and Edit Worksheet

Building and Editing Expressions – Variables and Constants – Units and Dimensions

Unit 2Computational Features

Vectors and Matrices – Operators – Integrals – Built-in Functions – Statistical Functions

Unit 3Solving Equations

Differential equations – Matrix equations – Integral equations – Optimization Symbolic calculations

Unit 4Graphics Features

Creating a graph – Graphing functions, vectors – Formatting graphs -labelling Modifying graph perspective

Unit 5Graphics Analysis

Gallery of graphs – Polar plots – Surface plots – Contour plots - Bar charts – scatter plots – graphical analysis

Textbook

MathCAD - User's Guide – MathCAD 7 Professional, 2000, MathSoft, USA.

Bloom's Taxonomy	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
CO1		2	3			
CO2			3	4		
CO3				4	5	
CO4			3	4	5	
CO5			3	4	5	

Mean : 7.5

PGP 422V X-ray Diffraction Techniques for Material Characterization 2Hrs./ 2Cr.

This course will enable the students to understand the fundamentals of X-ray Crystallography, experimental components and the basics of parameter determinations. This course will equip a student to handle X-ray information with ease. This course will enable a student familiarizing and handling related softwares.

This course will enable student to

i. understand the fundamentals of X-ray diffraction.
ii. students will be familiarized with hardwares involved in XRD.
iii. sample preparation will be mastered by the student
iv. basic parameter determinations will be known
v. research level softwares will be familiarized.

Unit 1 Fundamentals of X-ray diffraction 6 Hrs

Production and properties of X-ray, absorption of X-rays and filters, X-ray - diffraction directions, diffraction methods - X-ray-diffraction intensities,factors affecting intensity, structure factor calculations

Unit 2 X-ray Diffractometer 3 Hrs

Working principles of diffractometer, Powder XRD geometry, Single crystal X-ray diffractometer, Goniometer, counters and cameras

Unit 3Sample Preparation 3 Hrs

Powder sample preparation, Single crystal preparation, single crystal mount techniques

Unit 4Determination of basic parameters 10 Hrs

Understanding different formats of XRD data–PowderX software - Indexing of XRD patterns - Precise lattice parameter determination - Grain software - determination of particle size and micro/macro strains - Mercury software: Simulation of PXRD patterns, Crystal shape drawing.

Unit 5 Determination of crystal structure 8 Hrs

Jana2006 software – Preparing input data, Simple refinement of Single crystal XRD and Powder XRD patterns, Refinement of simple inorganic structure, Refinement of organic compound structure. Extracting parameters from output file.

Textbook

B.D.Cullity and S.R.Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall,NJ , 2001.

References
http://www.ccp14.ac.uk/tutorial/powderx/runthr.htm
http://jana.fzu.cz/,http://jana.fzu.cz/workshops/Jana2006%20Cookbook.pdf
http://www.ccdc.cam.ac.uk/mercury/

Bloom's Taxonomy	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
CO1	1	2				
CO2		2				
CO3			3	4		
CO4		2			5	
CO5			3			6

Mean : 4.6

PGP 521V *PYTHON for Physicists* *2Hrs./2Cr.*

This Course introduces students to scientific computing using PYTHON. It also equips them with necessary skills to automate data collection and logging.

At the end of the course, students will be able to

i. understand and write basic python programs
ii. use scipy and numpy modules for scientific computing
iii. plot and analyze data using python
iv. apply their python skills in laboratory calculation
v. automate data collection from sensors using raspberry pi and python.

Unit 1Basics of Python

Installing python- integrated development environment (IDE) – native data types- for loops- if statements- simple math operations – while loops – functions, classessimple programs

Unit 2 Scientific computation with python

Importing modules(scipy, numpy, matplotlib and pandas)–numpy arrays– solving linear equations– nonlinear equations– numerical integration

Unit 3Visualize data with python

Matplotlib– Basic plotting– logarithmic plot–contourand vector field plots – threedimensional plots- curve fitting

Unit 4 Working with lab data (Photoluminescence Spectroscopy)

Reading data from csv files- plotting emission and excitation spectra for unknown molecule- kataura plot for carbon nanotubes – interpreting results

Unit 5Sense, log and display data using python

Raspberry pi- connecting sensor to i2cbus– reading analog data using ADCloggingand plotting data– plotting live data– scaling and calibrating data

Textbooks

1. Introduction to Python for Science and engineering- David J. pine, 2019, CRC press
2. Raspberry Pi Cookbook for Python Programmers- Tim Cox, 2014, Packt publishing.

References

1. "A Practical Introduction to Python Programming" by Heinold, Licensed under Creative Commons Attribution-Noncommercial.
2. "Learning SciPy for Numerical and Scientific Computing" by Sergio J. Rojas G., Erik A Christensen, Francisco J. Blanco-Silva, 2nd Edition.
3. "Hello Raspberry Pi! Python programming for kids and other beginners" by Ryan Heitz, Manning Publications (2016).

Bloom's Taxonomy	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
CO1		2				
CO2			3	4		
CO3			3	4		
CO4				4		
CO5			3	4	5	

Mean : 5.3

PGP522V *Practical Astronomy* *2Hrs. / 2Cr*

This course is for students who have the desire to become familiar with thenature and motions of celestial objects in the night sky and learn the techniques to observe them. It gives a foundation in the subject which would be a platform for the students seeking higher studies and research work in the subject. The course includes theory classes, practical/project sessions and virtual field trips to Astronomical Observatories.

After successful completion of the course, students will be able to

i. compare and contrast the different understanding of the universe
ii. identify important constellations – orient in space.
iii. have skills to construct refracting telescopes.
iv. do photometry of stars
v. use open source software in astronomy

Unit 1 Introduction to cosmos

Greek Astronomy and astronomy in the era of Copernicus, Tycho, Kepler and Galileo – Earth's rotation and other motions – Changing night sky - celestial sphere and the coordinate systems – Exploring Star charts and identifying constellations.

Unit 2 Observational tools

Designing of refractive optical telescopes - Light gathering - Magnifying – Resolving powers – Measurement of stellar distances. Radio Telescopes – radial velocity determination - Introduction to Astrophotography

Unit 3 The nature of stars

The spectrum from the stars - Sun as a star - Spectral types of the stars – The hydrogen spectrum The continuous spectrum The Hertzsprung-Russell diagram - photometry of stars – measurement of solar limb darkening.

Unit 4 Eclipses

Solar eclipses – total-partial and annular –totality of the solar eclipse- Baily'sbeads– Solar Eclipse Timer – Lunar eclipses –total, partial and penumbral – Eclipse calendar app.

Unit 5 Virtual Sky and analysis of astronomical data

Stellarium-Sky Map – star mapping –the positions of the Sun and Moon, planets and stars- solar system virtual tour- NASA's OWN remote observatory (https://mo-www.cfa.harvard.edu/OWN/index.html) data analysis – surface brightness profile (brightness vs distance from the center) of the galaxy (M31, M101, and M51).

PGP8

Text Book

Cosmos: The Art and Science of the Universe, 2019 Roberta J.M. Olson and Jay M. Pasachoff

References

1. https://sites.williams.edu/eclipse/
2. http://stellarium.org/
3. https://www.solareclipsetimer.com/
4. https://openstax.org/books/astronomy/pages/1-introduction
5. http://va-iitk.vlabs.ac.in/
6. https://nineplanets.org/tour/

Bloom's Taxonomy	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
CO1	1					
CO2		2	3			
CO3				4		
CO4				4		
CO5					5	

Mean : 3.1