Vocational and Skill Based Courses

Programming in python

Course Code: PAS8106L **Course Type: Vocational/Skill**
Credits: 2

Course Objectives: *Proficiency in computer programming/coding has arguably become one of the most important skills a researcher needs in science today. There are a number of reasons for this, prime among them is, as a consequence of advances in tools and technology, researchers/post-graduate are now collecting and working with larger datasets. These datasets require computing coding and machine learning steps for carrying out efficiently an unbiased and large-scale analysis. There are many ways to learn how to code and it is important to identify the method that works best for your science project. First, you have to decide which computer language you are going to learn. A few of the bigger and recommended languages for science include Python, IDL, R, c++ etc. Among them, Python being both open sources as well as an interpreted language having so many packages in builts is commonly preferred in the present scenario.*

Learning Outcomes: *After completing the course satisfactorily, a student will be able:*

CO1: *To understand the technique in observational astronomy*
CO2: *To understand the distance ladder in the context of the size of the Universe*
CO3: *To understand the basic syntax of python*
CO4: *The use of importing library in python*
CO5: *Plotting techniques using the various python library*
CO6: *Use of numpy and astropy to illustrate python capability in array operation*
CO7: *Python library for matrices operation*
CO8: *Learn to use the various routines in scientific projects consisting of various parameter optimizations techniques.*

Course Contents:

Unit 1: Introduction, Using Code Examples How to Run Python Code, A Quick Tour of Python Language Syntax . **(5 Lectures)**

Unit 2: Basic Python Semantics: Variables and Objects, Basic Python Semantics: Operators Built-In Types: Simple Values, Built-In Data Structures, Control Flow . **(5 Lectures)**

Unit 3: Defining and Using Functions Errors and Exceptions Iterators, List Comprehensions, Generators . **(5 Lectures)**

Unit 4: Modules and Packages, String Manipulation and Regular Expressions, A Preview of Data Science Tools . **(5 Lectures)**

Unit 5: Finally, a basic query for data mining from large science experiments and surveys (e.g in astronomical sciences), based on mysql and php programming, optimized by a set of constraints by taking some examples of research projects, will also be covered. For

further advancement, a few examples by using codes publically available in GitHub repository which are also relevant for the area of research being pursued at the university will be discussed by using them as subroutines in our planned main codes, so as to learn their use to carry out an unbiased and large-scale analysis of large datasets exist in various public archives. **(10 Lectures)**

Prescribed Text Book:

1. A Whirl Wind Tour of Python, by Jake Vande Plas.

Course Articulation Matrix of PAS8106L- Programming in Python

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	1	3	3	2	1	3
CO2	3	2	3	1	2	3	2	1	1	1
CO3	2	2	2	3	3	1	3	1	2	2
CO4	2	2	3	1	1	3	3	3	1	2
CO5	2	1	2	2	2	1	1	2	2	1
CO6	3	1	2	1	1	1	1	1	1	3
CO7	2	2	3	2	1	1	3	3	1	3
CO8	1	1	2	1	2	3	1	3	2	3

1: Partially related
2: Moderately related
3: Strongly related

Nuclear Radiation and Safety

Course Code: PAS92XX **Course Type: Vocational/Skill**
Credits: 2

Course Objectives: *The main aim of this course is to make you aware and understand the radiation hazards and safety. Students renew and expand their knowledge on nucleus and atom structure, and get basis of: different kinds of radioactive transformations, interactions of radiation with matter and its effects on living cells, detection of different kind of radiation, procedures of handling with radiation sources and applying radiation protection, basic knowledge of national and international legislation and recommendations in radiation protection. Students will become capable to implement the fundamental knowledge into everyday life and to critically consider benefits and risks of radiation.*

Course Outcomes: After the completion of the course, the student will be able to:

CO1: *Understand the consequences of poor safety with regard to handeling radioactive sources and nuclear radiations, in general.*
CO2: *Be aware of and understand the key factors influencing the basis for nuclear safety.*
CO3: *Understand the hazards associated with nuclear plant and how risks can be controlled.*
CO4: *Get required to work in a radiation prone allied research fields.*

Course Contents

Unit 1: Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. **(7 Lectures)**

Unit 2: Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photoelectric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation. **(7 Lectures)**

Unit 3: Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetery. **(10 Lectures)**

Unit 4: Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. **(6 Lectures)**

Prescribed Text Books:

1. Introductory Nuclear Physics, K. S. Krane, John Wiley& Sons Ltd
2. An Introduction to Nuclear Physics, W. N. Cottingham, D. A. Greenwood, Cambridge University Pres.
3. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
4. Elements of Nuclear Physics, Walter E. Meyerhof, McGraw-Hill Book Company.

Course Articulation Matrix of PAS92XX- Gravitation and Cosmology-I

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	1	3	1	3	1	2	2	3
CO2	2	1	3	3	1	1	2	2	1	1
CO3	3	2	3	1	3	1	1	2	3	3
CO4	2	3	2	1	2	3	3	1	3	1

1: Partially related
2: Moderately related
3: Strongly related

Practical: General Physics

Course Code: PASPAS8105L **Course Type: Vocational/Skill**
Credit: 2
Course Objectives: *The course is designed to perform experiments and simulations to go hand in hand with the theory courses on Classical Mechanics and Electro-Dynamics , All the experiments shall be based on two techniques, Video Motion Based Analysis using Tracker, Data Acquisition using Expeyes kit. All the simulations shall be performed in Scilab.*

Course Outcomes: *By the end of the three-course intro lab sequence, students should be able to:*

CO1: *Collect data and revise the experimental procedure iteratively, reflectively, and responsively.*
CO2: *Evaluate the process and outcomes of an experiment quantitatively and qualitatively*
CO3: *Extend the scope of an investigation whether or not results come out as expected*
CO4: *Conduct an experiment collaboratively and ethically*

List of Experiments:

Lab 1: Simple Pendulum Experiment for small and large angle oscillations

- Introduction to Video Analysis using Tracker.
- Importance of matching the experimental outcomes with theoretically expected results.
- Extension: to study damped harmonic oscillator
- Simulation of the experiment using xcos in Scilab

Lab 2: Coupled Oscillator Experiment

- Normal mode oscillations
- Transfer of energy between the two oscillators
- Determination of g by varying the height of coupling between the oscillators
- Simulation of the experiment using xcos in Scilab

Lab 3: Double Mass Spring System/Double Pendulum

- Obtaining the frequencies of the system and comparision with the theoretically expected result.
- Simulation using xcos in Scilab

Lab 4: Variable Mass-spring system

- To determine the rate of loss of sand with increasing hole size
- To determine the variation in amplitude w.r.t. to rate of loss of mass, for different hole sizes
- Simulation using xcos

Lab 5: Fourier Analysis using Electrical and Electronic circuits

- Obtain the fourier components and co-efficients of a square wave using a LCR circuit
- Obtain the fourier components and co-efficients using op-amp filter circuits

Lab 6: Verification of Fresnel's Equations

- Production and Analysis of linearly and circularly polarised light
- Angular dependence of reflection and transmission
- To explore Brewster's law and find Brewster angle

Lab 7: Dielectric constant of liquids using Colpitts oscillator

Lab 8: Zeeman Effect

Lab 9: Magnetic Susceptibility of a paramagnetic liquid

Reference: Departmental Lab Manuals.

Course Articulation Matrix of PAS8105L- General Physics Lab

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	3	2	2	3	1	3
CO2	2	1	2	3	2	1	1	1	1	1
CO3	1	3	2	3	3	3	1	1	2	2
CO4	1	2	3	3	2	3	2	2	1	1

1: Partially related
2: Moderately related
3: Strongly related

Computational Physics Laboratory

Course Code: **PAS8206L** **Course Type: Vocational/Skill**
Course Credit: 2

Course Objectives: *The students will be exposed to the basic working of computer in the context of modelling some simple systems. To understand the logical structure of the problem and its implementation on the computer. It, also, includes the use of basic mathematical and numerical techniques in computer calculations leading to solutions for typical physical problems.*

Course Outcomes;
After the completion of the course, student shall be able to:

CO1: *develop a logical way of implementing the constraints of the given physical system and transforming them into a numerical code.*

CO2: *They will be able to numerically solve the equations of motions of some simple systems. In this way they will be able to understand the requirement of a good code and the things required to make it more accurate and time efficient.*

Statistical Mechanics Simulations:

Worksheet based Simulations:

Lab 1: Microstates, Macrostates and Steady-state equllibrium
Lab 2: Ergodic Hypothesis Demonstration

Simulations in Scilab:

Lab 3: Boltzmann Distibution: P(E) vs E
Lab 4: Boltzmann Speed Distribution and Maxwell's velocity distribution
Lab 5: Joule's Expansion and Entropy

Quantum Mechanics Simulations:

Lab 6: Solving the Time-Dependent Schrodinger Equation and obtaining the spreading of Gaussian wavepacket
Lab 7: Studying the Scattering of Gaussian wavepacket
Lab 8: Scattering from a step potential and a barrier potential

Manuals will be provided during the lab sessions.

Course Articulation Matrix of PAS8206L- Computational Physics Lab

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	1	2	1	1	1	1	2
CO2	3	3	3	1	3	1	1	2	2	3

1: **Partially related**
2: **Moderately related**
3: **Strongly related**

Semiconductor Devices

Course Code: PAS9XXX **Course Type: Vocational/Skill**

Course Credit: 2

Course Objectives:

Applications in solving problems of interest to physicists. Explore the potential application of semiconducting devices.

Course Outcomes:

CO1: *Explains the working principle of a p-n junction.*

CO2: *Describes electronic behavior of a diode in a circuit.*

CO3: *Explains current-voltage characteristics of a diode under forward and reverse bias.*

CO4: *Explains the working principle of a junction transistor.*

CO5: *Explains the behavior of carriers in a junction transistor.*

CO6: *Explains current-voltage characteristics in a field effect transistors.*

CO7: *Explains the working principle of a metal oxide field effect transistor.*

CO8: *Explains how the metal-semiconductor contacts will occur.*

CO9: *Defines the ohmic and Schottky contact.*

Course Contents

Unit 1: Semiconductor Materials (4 Hours)

- Charge Carriers in Semiconductors
- Dopant Atoms & Energy levels
- The Extrinsic Semiconductors
- Statics of Donors & Acceptors
- Charge Neutrality

Unit 2: Carrier Transport in Semiconductors (6 Hours)

- Carrier Drift (Drift Current, Mobility, Conductivity)
- Carrier Diffusion (Diffusion Current Density, Total Current Density)
- Graded Impurity Distribution (Induced Electric Field, The Einstein Relation)
- Carrier Generation and Recombination
- Characteristics of Excess Carrier
- Ambipolar Transport

Unit 3: The p-n Junction (4 Hours)

- Basic Structure of the pn Junction

- Zero Applied Bias
- Reverse Applied Bias
- pn Junction Current

- Small-Signal Model of the pn Junction
- Generation-Recombination Current
- Junction Breakdown

Unit 4: The Bipolar Transistor (3 Hours)

- The Bipolar Transistor Action
- Minority Carrier Distribution
- Low Frequency Common-Base Current

Unit 5: Metal-Semiconductor Junction: (3 Hours)

- The Schottky Barrier Diode
- Metal-Semiconductor Ohmic Contacts
- Heterojunctions

Prescribed Textbooks:

1. Semiconductor Physics & Devices, D. A. Neamen, Mc Graw Hill (2003).
2. Semiconductor Device Physics and Technology, S.M Sze, Wiley (1985).

Other Resources/Reference books:

1. Introduction to Semiconductor Devices, M. S. Tyagi, John Wiley & Sons.
2. The Physics of Semiconductor Devices, D.A. Eraser, Oxford Physics Series (1986).
3. Semiconductor Devices: Basic Principles, Jasprit Singh, Wiley (2001).

Course Articulation Matrix of PAS9XXX- Semiconductor Devices

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	3	3	1	3	1	2
CO2	3	3	3	1	1	2	2	3	1	1
CO3	3	3	1	1	2	1	2	2	2	1
CO4	2	3	2	2	2	3	2	1	3	1
CO5	1	1	1	1	2	2	2	2	2	2
CO6	1	3	1	1	2	2	2	3	1	1
CO7	1	2	3	3	1	1	2	2	2	3
CO8	1	3	3	3	3	2	1	1	2	3
CO9	3	3	2	2	2	3	1	1	3	2

1: Partially related
2: Moderately related
3: Strongly related

Interdisciplinary Courses (IDC)

Mathematical Techniques

Course Code: PAS8103 **Course Type: IDC Major**
Course Credit: 2

Course Objectives:
The course aims to familiarize students to, Matrices, determinants and linear systems, Vector differential calculus, Complex numbers and functions Complex integration

Course Outcomes:
This gives details about the Mathematical Techniques offered for Master in Science (M Sc) course in the department of Physics and Astronomical Sciences. After getting this course the student will be acquainted with the basic principles Mathematical Techniques.
The students will have understanding of:

CO1: *Basic and advanced mathematical tools required for Physics Problems.*
CO2: *Different Techniques to solve differential and integral equations.*
CO3: *Various special functions and important transforms and their applications*
CO4: *They will understand (i) Complex analysis and integration. Also, knowledge shall be gained in areas like (i) Linear Vector Space and operator algebra, (ii) matrix diagonalization and series of matrices,and (iii) Green's functions.*

Course Contents

Unit 1: Matrices and their applications-I (4 hours)

- Matrices and their operations, linear transformations, special matrices, orthogonal and unitary matrices.
- System of linear equations, augmented matrix, rank of matrix,
- Gauss elimination and Gauss Jordan methods.
- Linear dependence of vectors and *n*-dimensional space, orthonormal basis and Garm-Schmidt method.

Unit 2: Matrices and their applications-II (4 hours)

- Matrix eigenvalues, eigenvectors of a matrix, Cayley-Hamilton theorem.
- Theorems about eigen values and applications.
- Coordinate transformations and matrices. Linear and similarity transformations.
- Diagonalization of matrices.

Unit 3: Complex numbers and functions (4 hours)

- Complex numbers and complex plane, Polar form of complex number, roots,
- Derivative and analyticity, Cauchy-Riemann equations,
- Analyticity and Laplace's equations.
- Complex form of exponential, trigonometric, hyperbolic and logarithmic functions.

Unit 4: Complex integration-I (4 hours)

- The line integral in a complex plane, ML inequality, Cauchy's integral theorem
- Cauchy's integral formula, n-th order derivatives of analytical function, Cauchy's inequality

- Power, Taylor, Maclaurin and Laurent series, Radius of convergence

- Singularities and zeros, Zeros of an analytical function.

Unit 5: Complex integration-II **(4 hours)**

- Laurent series and Residue integration method.
- Calculating residues
- Residue theorem.
- Applications of residue theorem to solve integrals in complex plane.

Prescribed Textbooks (Key texts):

1. Mathematical Methods for Physicists by G. Arfken and H.J. Weber , Elsevir Academic Press
2. Mathematical Methods in the Physical Sciences by W.L. Baos, John Wiley & Sons

Other Resources/Reference books:

1. Advanced Engineering Mathematics by Erwin Kreyszic, John Wiley & Sons
2. Explorations in Mathematical Physics: The Concepts Behind an Elegant Language by Don Koks, Springer Science
3. Mathematical Physics by B.S. Rajput, Pragti Prakashan
4. Mathematical Methods in the Physical Sciences by W.L. Baos, John Wiley & Sons
5. Advanced Engineering Mathematics by Peter V. O'Neil, Thomson

Course Articulation Matrix of PAS8103- Mathematical Techniques

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	2	1	3	3	3	3
CO2	3	2	1	3	3	3	2	2	1	2
CO3	2	1	2	3	1	3	1	2	2	1
CO4	2	2	2	3	2	3	1	2	1	2

1: Partially related
2: Moderately related
3: Strongly related