University School of Vocational Studies and Applied Sciences (USoVSAS)
Department of Applied Physics

B.Sc. (Honours) Physics
&
B.Sc (Honours with Research) Physics

As per the curriculum and credit framework of National Education Policy 2020

COURSE STRUCTURE AND SYLLABUS

Exit options as per NEP course structure:

- An UG certificate after completing 1 year (2 semesters) of study in the chosen fields of study, with mandatory summer internship of 08 weeks duration/ a vocational course of 4 credits during summer vacation. The students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

- An UG diploma after 2 years (4 semesters) of study, with mandatory summer internship of 08 weeks duration/ a vocational course of 4 credits during summer vacation. The students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

- A bachelor's degree after a 3-year (6 semesters) programme of study, with mandatory summer internship of 08 weeks duration.

- A 4-year bachelor's degree (honours) after eight semesters programme of study. If the student completes a rigorous research project in their major area(s) of study in the 4th year of a bachelor's degree (honours with research). However, summer internship of 08 weeks duration is mandatory for fulfilment of degree requirement.

- **Requirements for Major and Minor disciplines:**

  (A) Student may opt for a single Major discipline (i.e., Physics) or can opt for a minor in some other discipline along with the major discipline.

  Three year degree requirement: 60 Major Credits from core discipline, 24 Minor Credits from generic elective (GE) courses from a specific minor discipline.

  Four year degree requirement: 80 Major Credits from core discipline, 32 Minor Credits from generic elective (GE) courses from a specific minor discipline.

  (B) Students with Major in Physics and Minor in some other branch may choose the minor discipline from the program where NEP curriculum is followed. GE courses will be offered by the department in which the student requires Minor Degree – depending upon the resources available and subject to minimum number of students opting for it.

  (C) The students opting for a Minor degree in Physics (having taken Major in any other discipline where NEP curriculum is followed) may choose the GE courses offered by the Applied Physics Department from the courses listed in **Table 3**.

Course Structure for Four-Year UG Programme in Physics (As per NEP-2020)
Programme Name: B.Sc. (Hons.) Physics
[Academic session 2023-24 onwards]

Total Credits = 180

	First Year; First Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH111	Mechanics	4	4-0-0
CC: PH113	Mechanics Laboratory	2	0-0-2
CC: PH115	Mathematical Physics-I	4	4-0-0
CC: PH117	Mathematical Physics-I Laboratory	2	0-0-2
IDC-1	**List 1**	3	3-0-0
AEC-1: ES101	Environmental Studies	4	4-0-0
SEC1	**Table 1**	3	2-0-1
VAC-1:	**List 2**	2	2-0-0
	Credits Sub-total	**24**	**19-0-5**

	First Year; Second Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH112	Electricity and Magnetism	4	4-0-0
CC: PH114	Electricity and Magnetism Laboratory	2	0-0-2
CC: PH116	Waves and Optics	4	4-0-0
CC: PH118	Waves and Optics Laboratory	2	0-0-2
IDC-2	**List 1**	3	3-0-0
AEC-2: EN-105	Communicative English	4	4-0-0
SEC2	**Table 1**	3	2-0-1
VAC-2:	**List 2**	2	2-0-0
	Credits Sub-total	**24**	**19-0-5**
Students exiting the programme after securing 48 credits will be awarded UG Certificate in the relevant Discipline /Subject provided they secure additional 4 credits during the first year summer term in work based learning/ internship.			**Cumulative credits 48**

PHI100	*Summer Internship of 08 weeks duration for students who wish to exit after 2 Semester of study*	**04**	**NA**

	Second Year; Third Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH211	Mathematical Physics-II	4	4-0-0
CC: PH213	Mathematical Physics-II Laboratory	2	0-0-2
CC: PH215	Thermal Physics	4	4-0-0
CC: PH217	Thermal Physics Laboratory	2	0-0-2
CC: PH219	Digital Systems and Applications	4	4-0-0
CC: PH221	Digital Systems and Applications Laboratory	2	0-0-2
IDC-3	**List 1**	3	3-0-0
SEC-3:	**Table 1**	3	2-0-1
VAC-3:	**List 2**	2	2-0-0
	Credits Sub-total	**26**	**19-0-7**

	Second Year; Fourth Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH212	Mathematical Physics-III	4	4-0-0
CC: PH214	Mathematical Physics-III Laboratory	2	0-0-2
CC: PH216	Elements of Modern physics	4	4-0-0
CC: PH218	Elements of Modern physics Laboratory	2	0-0-2
CC: PH220	Analog Systems and Applications	4	4-0-0
CC: PH222	Analog Systems and Applications Laboratory	2	0-0-2
DSE1/ GE1	**Table 2**	4	3-0-1/ 4-0-0
	Credits Sub-total	**22**	**15-0-7**
Students exiting the programme after securing 96 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 4 credits during first year or second year summer term in work based learning/ internship.			**Cumulative Credits 96**
PHI200	*Summer Internship of 08 weeks duration for students who wish to exit after 4 Semester of study and did not opt for the work-based learning/ internship during the Summer Term of first year.*	**04**	**NA**

	Third Year; Fifth Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH311	Quantum Mechanics and Applications	4	4-0-0
CC: PH313	Quantum Mechanics Laboratory	2	0-0-2
CC: PH315	Solid State Physics	4	4-0-0
CC: PH317	Solid State Physics Laboratory	2	0-0-2
DSE2/ GE2	**Table 2**	4	4-0-0
DSE3/ GE3	**Table 2**	4	4-0-0
DSE4/ GE4	**Table 2**	4	4-0-0
	Credits Sub-total	**24**	**20-0-4**

	Third Year; Sixth Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH312	Electromagnetic Theory	4	4-0-0
CC: PH314	Electromagnetic Theory Laboratory	2	0-0-2
CC: PH316	Statistical Mechanics	4	4-0-0
CC: PH318	Statistical Mechanics Laboratory	2	0-0-2
DSE5/ GE5	**Table 2**	4	4-0-0
DSE-6/ GE-6	**Table 2**	4	4-0-0
	Credits Sub-total	**20**	**16-0-4**
Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline / Subject upon securing 144 credits including the work based learning/ internship during the Summer Term of 1st, 2nd or 3rd year. Students who chooses the exit option after 3rd year may opt for a summer internship for longer duration.			**Cumulative Credits 134**

PHI300	*Summer Internship of minimum 08 weeks duration mandatory for all students who did not opt for the work-based learning/ internship during the Summer Term of first or second year.*	**04**	**NA**

	Fourth Year; Seventh Semester		
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH411	Semiconductor Physics and Devices	4	4-0-0
CC: PH413	Semiconductor Physics Laboratory	2	0-0-2
CC: PH415	Research Methodology	4	4-0-0
SEC4	**Table 1**	3	2-0-1
PH421	**Minor Project**	6	0-0-6
PH423	Institutional/ Laboratory visit	1	0-0-1
	Credits Sub-total	**20**	**16-0-4**

Fourth Year; Eighth Semester			
(A) For B.Sc. (Hons.) with Course Work			
Course Code	**Course Name**	**Credits**	**L-T-P**
CC: PH412	Atomic and Molecular Physics	4	4-0-0
CC: PH414	Nuclear and Particle Physics	4	4-0-0
DSE-7/ GE-7	**Table 2**	4	4-0-0
DSE-8/ GE-8	**Table 2**	4	4-0-0
PH426	Literary Project/ MOOC Courses	2	0-0-2
VAC4	**List2**	2	2-0-0
	Credits Sub-total	**20**	**17-0-3**
Cumulative Credits = 174			

Fourth Year; Eighth Semester			
(B) For B.Sc. (Hons.) with Research			
Course Code	**Course Name**	**Credits**	**L-T-P**
DSE-7/ GE-7	**Table 2**	4	4-0-0
DSE-8/ GE-8	**Table 2**	**4**	**4-0-0**
PH428	Research Project/ Dissertation	**12**	0-0-12
	Credits Sub-total	**20**	**4-0-16**
Cumulative Credits = 180			

Abbreviations: **CC**=Core Course; **AEC** = Ability Enhancement Course; **VAC** = Value-Added Course; **SEC** = Skill Enhancement Course; **IDC** = Interdisciplinary Course.

TABLE 1: Skill Enhancement Courses (SEC): Credit-03 (2-0-1)

S. No.	SEC-1	SEC-2
1.	PH119 - Introductory MATLAB Programming	PH120 - Introduction to Office Automation and LaTeX
2.	PH121- Introduction to SciLab	PH122 - Introduction to Python
	SEC-3	**SEC-4**
1.	PH223 - Fundamentals of digital image processing	PH417 – Introduction to Cloud Computing
2.	PH225 - Introduction to Machine Learning	PH419 – Statistics with 'R'
Or any other course from the relevant discipline of importance		

LIST 1

Inter-disciplinary courses (IDC) from the following Departments/Disciplines subject to approval from the department of Applied Physics –IDC-1 to IDC-3, Credits-03 (3-0-0)

1. Department of Applied Mathematics
2. Department of Applied Chemistry
3. Department of Environmental Science
4. Department of Food Processing and Technology
5. Department of Economics Planning and Development
6. Department of Computer Science and Engineering
7. Department of Electronics and Communication Engineering
8. Department of Information Technology
9. Department of Electrical Engineering
10. Department of Mechanical Engineering
11. Department of Civil Engineering
12. Department of Architecture and Planning
13. Department of Biotechnology
14. School of Law, Justice and Governance
15. School of Humanities and Social Sciences
16. School of Management

OR any other discipline of importance.

Inter-disciplinary courses (IDC) for other Departments / Disciplines, Credit-03 (3-0-0)

Semester I
1. PH123 - Mechanics
2. PH125 - Mathematical Physics

Semester II
1. PH124 - Electricity and Magnetism
2. PH126 - Waves and Optics

Semester III
1. PH227 - Thermal Physics and Statistical Mechanics
2. PH229 - Elements of Modern Physics

LIST 2

Value Addition Courses: Credit-02 (2-0-0)

1. Social and Emotional Well-being
2. Ethics and Culture
3. Innovation and Entrepreneurship
4. Vedic Mathematics
5. Hindi Language and Literature
6. Living with Stress
7. Nutrition and Well-being
8. Drama and Art Education
9. Life and Skill Education
10. Physics of Household Appliances (PHVAC01)
11. Physics of Planets (PHVAC02)
12. Physics of Earth (PHVAC03)

OR any other relevant course of importance.

TABLE 2

Discipline Specific Elective (DSE) Courses: Credit-04 (4-0-0/ 3-0-1)

Semester IV	
S. No.	**DSE-1**
1.	PHUD224 - Fundamentals of Electro-optics and Photonics PHUD224L - Fundamentals of Electro-optics and Photonics laboratory
2.	PH226- Experimental Techniques
Semester V	
	DSE-2
1.	PH319 - Classical Dynamics and Relativity
2.	PH321 - Atmospheric Physics
	DSE-3
	PH323 - Numerical Analysis
	PH325 - Renewable Energy and Energy Harvesting
	DSE-4
1.	PH327 - Optical Communications
2.	PH329- Radiation Physics
Semester VI	
	DSE-5
1.	PH320- Advanced Quantum Mechanics
2.	PH322 - Spectroscopic Techniques
	DSE-6
1.	PH324- Nanoscience and Nanotechnology
2.	PH326 - Biophysics and Applications
Semester VIII	
	DSE-7
1.	PH416 - Photolithography and Devices Fabrication Techniques
2.	PH418 - Characterization Techniques
	DSE-8
1.	PH420 - Quantum Technologies
2.	PH422 - Astronomy and Astrophysics
3.	PH424 - Thin Film Technology and Vacuum Science

Table 3

Generic Elective (GE) courses for the students of other departments for obtaining Minor Degree in Physics, Credits: 04 (4-0-0/ 3-0-1)

S. No.	Course Code and Name	Credits
1.	PH123 - Mechanics PH123L - Mechanics laboratory	(3-0-0) (0-0-1)
2.	PH125 - Mathematical Physics PH125L- Mathematical Physics Laboratory	(3-0-0) (0-0-1)
3.	PH124 - Electricity and Magnetism PH124L - Electricity and Magnetism Laboratory	(3-0-0) (0-0-1)
4.	PH126 - Waves and Optics PH126L - Waves and Optics Laboratory	(3-0-0) (0-0-1)
5.	PH215 – Thermal Physics	(4-0-0)
6.	PH229 - Elements of Modern Physics PH229L - Elements of Modern Physics Laboratory	(3-0-0) (0-0-1)
7.	PH226 - Experimental Techniques	(4-0-0)
8.	PH311 - Quantum Mechanics and Applications	(4-0-0)
9.	PH315 - Solid State Physics	(4-0-0)
10.	PH312 - Electromagnetic Theory	(4-0-0)
11.	PH316 - Statistical Mechanics	(4-0-0)

Generic Electives (GE-1 to GE-8) for fulfillment of Minor Degree from other departments are subject to approval from the Department of Applied Physics, Credits-04 (4-0-0/ 3-0-1))

04 Years "B.Sc. (Honours/Research) in Physics" Programme [NEP-2020]

Category-wise Summary

Semester	Discipline Specific Courses –Core (DSC)/Major	Discipline Specific Electives (DSE)/ Generic Electives (GE)/ Minor **(To be chosen from the Pool of DSE/GE(Minor Courses)**	Inter-disciplinary courses (IDC) **(To be chosen from the Pool of IDC Courses)**	Ability Enhancement courses (language) (AEC)	Skill Enhancement courses (SEC) /Internship /Dissertation **(To be chosen from the Pool of SEC Courses)** TABLE 1	Common Value-Addition Courses (VAC) **(To be chosen from the Pool of VAC Courses)**	Total Credits
I	CC-1 (4+2) CC-2 (4+2)	-	IDC-1 (3)	AEC-1 (4)	SEC-1 (3)	VAC-1 (2)	24
II	CC-3 (4+2) CC-4 (4+2)	-	IDC-2 (3)	AEC-2 (4)	SEC-2 (3)	VAC-2 (2)	24
	work based learning/ internship. Mandatory for Students exiting the programme after securing 52 credits. Optional for all other students.						**(04)**
III	CC-5 (4+2) CC-6 (4+2) CC-7 (4+2)	-	IDC-3 (3)	-	SEC-3 (3)	VAC-3 (2)	26
IV	CC-8 (4+2) CC-9 (4+2) CC-10 (4+2)	DSE-1 (4)/ GE-1 (4)	-	-	-	-	22
	work based learning/ internship. Mandatory for Students exiting the programme after securing 100 credits. Optional for all other students.						**(04)**
V	CC-11 (4+2) CC-12 (4+2)	DSE-2/ GE-2 (4) DSE-3/ GE-3 (4) DSE-4/ GE-4	-	-	-	-	20
VI	CC-13 (4+2) CC-14 (4+2)	DSE-5/ GE-5 (4) DSE-6/ GE-6 (4)	-	-	-	-	20

	work based learning/ internship. Mandatory for all students yet to opt for work based learning/ internship at the end of first or second year of study.						**(04)**
VII	CC-15 (4+2) CC-16 (4)	-	-	-	SEC-4 (3) Minor Project (6) Institutional/ Laboratory visit (1)	-	20
VIII	CC-17(4) CC-18 (4)	DSE-7/ GE-7 (4) DSE-8/ GE-8 (4)	-		Literary Project (2)/ MOOC courses (2)	VAC-4 (2)	20
VIII		DSE-7/ GE-7 (4) DSE-8/ GE-8 (4)			Research Project/ Dissertation (12)		20
	94/102	32	09	08	29/21	08	**180**

Syllabus of the 04 Years "B.Sc. (Honours/Research) in Physics" Programme

[NEP-2020]

[Academic session 2023-24 onwards]

DISCIPLINE SPECIFIC CORE COURSES/Major

Semester I

PH 111-MECHANICS
Credits-04 (4-0-0)

Course objectives: *This course comprises the study of basic concepts and formulations of Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Moreover, students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the understanding of the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numerical in mechanics.*

Fundamentals of Dynamics: Review of Newton's laws of motion, Principle of conservation of momentum, Dynamics of a system of particles, determination of Centre of Mass of discrete and continuous objects.

Work and Energy: Work and kinetic energy theorem, Conservative and non-conservative forces, potential energy, energy diagram, Force as gradient of potential energy, Work done by non-conservative forces, Law of conservation of energy, Elastic and inelastic collisions, Centre of mass.
Rotational Dynamics: Angular momentum of a particle and system of particles, Torque, Principle of conservation of angular momentum, Rotation about a fixed axis, Moment of inertia, theorem of parallel and perpendicular axes (statements only), Determination of moment of inertia of discrete and continuous objects, Kinetic energy of rotation, Motion involving both translation and rotation.
Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Potential and field due to spherical shell and solid sphere, Two-body problem and its reduction to one-body problem with solution, Reduction of angular momentum, kinetic energy and total energy, the energy equation and energy diagram, Kepler's Laws, Satellite in circular orbit, Geosynchronous orbits.

Oscillations: Idea of Simple Harmonic Motion (SHM), Differential equation of SHM and its solution, Kinetic energy, potential energy, total energy and their time-average values, Compound pendulum, Damped oscillation, Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.
Special Theory of Relativity: Inertial and non-inertial frames of reference, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity, Length contraction, Time dilation, Relativistic transformation of velocity, Variation of mass with velocity, Massless Particles, Mass-energy Equivalence, Relativistic Doppler effect, Relativistic Kinematics, Transformation of energy and momentum.

Texts/ References:

1. An Introduction to Mechanics, Daniel Kleppner & Robert Kolenkow, 2007, Tata McGraw Hill
2. Mechanics, D S Mathur, P S Hemne, 2012, S. Chand
3. University Physics, F W Sears, M W Zemansky & H D Young 13/e, 1986, Addison Wesley
4. Mechanics Berkeley Physics course, v.1: Charles Kittel, et.al. 2007, Tata McGraw Hill
5. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
6. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

PH 113-MECHANICS LAB

Credits: 02 (0-0-4)

Course objectives: *This laboratory provides the practical knowledge about laws of motion, moment of inertia and gravitation etc. Students would also get familiar with various measuring instruments and would learn the importance of accuracy of measurements.*

At least 08 experiments from the following:

1. Measurements of length (or diameter) using Vernier calipers, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.
13. To determine the value of g using simple pendulum.
14. To determine the moment of inertia of an irregular body about an axis passing through it and perpendicular to its plane by dynamical method (Inertia table).
15. To determine the spring constant by Hooke's law
16. To determine the Poisson ratio of rubber.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. Practical Physics, G L Squires, 2015, 4th Edition, Cambridge University Press
5. A Text Book of Practical Physics, I Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

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PH 115-MATHEMATICAL PHYSICS-I

Credits: 04 (4-0-0)

Course objectives: *The objective of the respective course is to enhance the understanding of mathematical tools in solving problems of interest to physicists. By the end of this course, students are to be examined based on problems, seen and unseen.*

Vector Algebra: Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively, Scalar and vector fields.
Vector Differentiation: Directional derivatives and normal derivative, Gradient of a scalar field and its geometrical interpretation, Divergence and curl of a vector field, Del and Laplacian operators, Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical coordinate systems.
Vector Integration: Ordinary integrals of vectors, Double and triple integrals, change of order of integration, Jacobian, Notion of infinitesimal line, surface and volume elements, Line, surface and volume integrals of vector fields, Flux of a vector field, Gauss' divergence theorem, Green's and Stokes theorems and their verification (no rigorous proofs).

First Order Differential equations: First Order Differential equations: variable separable, homogeneous, non-homogeneous, exact and inexact differential equations and integrating factor.
Second Order Differential equations: Homogeneous equations with constant coefficients, Wronskian and general solution, Particular Integral with operator method, method of undetermined coefficients and variation method of parameters, Euler differential equation and simultaneous differential equations of first and second order.
Matrix algebra: Solution of linear algebraic equations, characteristic equation, eigen values and eigen vectors, Cayley-Hamilton theorem, functions of matrices, application in solving linear differential equation.

Texts/References:

1. Mathematical Methods for Physicists, G B Arfken, H J Weber, F E Harris, 2013, 7th Edn., Elsevier
2. An introduction to ordinary differential equations, E A Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill
4. Advanced Engineering Mathematics, D G Zill and W S Wright, 5 Ed., 2012, Jones and Bartlett Learning
5. Vector Analysis: Schaum's Outlines Series, M Spiegel, S Lipschutz, 2017, 2nd Edition, McGraw-Hill
6. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
7. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India

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PH 117-MATHEMATICAL PHYSICS-I LAB

Credits: 02 (0-0-4)

Course objectives: *This laboratory would introduce students with the basic knowledge of scientific programming languages and implementation of C++/C/Scilab simulations for Mathematical Physics problems.*

At least 10 programs must be attempted from the following:

Introduction and Overview: Computer architecture and organization, memory and Input/output devices.
Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and repetition, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods, Algorithms and Flow charts: Purpose, symbols and description.
Introduction to C++: Introduction to Programming: Algorithms: Sequence, Selection and repetition, Structured programming, basic idea of Compilers, Data Types, Enumerated Data, Conversion and casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators, Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables.
C++ Control Statements and loops: if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Go to statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements.

Programmes:

1. To calculate area of a rectangle.
2. To check size of variables in bytes (Use of size of ( ) Operator).
3. To find roots of a quadratic equation.
4. To find largest of three numbers.
5. To check whether a number is prime or not.
6. To list Prime numbers up to 1000.
7. To find the sum and average of a list of numbers.
8. Program to check whether even or odd number.
9. To find the largest of a given list of numbers and its location in the list.
10. Sorting of numbers in ascending and descending order using Bubble sort, Sequential sort or Binary search.

11. To generate the Fibonnaci series.
12. To find the factorial of a number.

Texts/References:

1. Schaum's Outline of Programming with C++, J Hubbard, 2000, McGraw-Hill Pub
2. Numerical Recipes in C^{++}: The Art of Scientific Computing, W H Press et. al., 2^{nd} Edn., 2013, Cambridge University Press
3. An introduction to Numerical methods in C^{++}, Brian H. Flowers, 2009, Oxford University Press

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Semester II

PH 112-ELECTRICITY AND MAGNETISM

Credits: 04 (4-0-0)

Course objectives: *The course covers static and dynamic electric and magnetic field, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. Moreover, student will be able to appreciate Maxwell's equations.*

Electric Field and Electric Potential: Electric field: Electric field lines, Electric flux, Gauss' law with applications to charge distributions with spherical, cylindrical and planar symmetry, Conservative nature of Electrostatic field, Electrostatic potential, Laplace's and Poisson equations, The Uniqueness theorem, Potential and electric field of a dipole, Force and torque on a dipole, Electrostatic energy of system of charges, charged sphere, Conductors in an electrostatic field, Surface charge and force on a conductor, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor, Method of Images and its application to (i) Plane infinite sheet and (ii) Sphere.
Dielectric Properties of Matter: Electric Field in matter, Polarization, Polarization charges, Electrical susceptibility and dielectric constant, Capacitor (parallel plate, spherical, cylindrical) filled with dielectric, Displacement vector **D**, Relations between **E**, **P** and **D**, Gauss' law in dielectrics.
Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**, Biot-Savart's law and its simple applications: straight wire and circular loop, Current loop as a magnetic dipole and its dipole moment, Ampere's circuital law and its application to (i) Solenoid and (ii) Toroid, Properties of **B**: curl and divergence, Vector potential, Magnetic force on (i) point charge (ii) current carrying wire (iii) between current elements, Torque on a current loop in a uniform magnetic field.
Magnetic Properties of Matter: Magnetization vector (**M**), Magnetic intensity (**H**), Magnetic susceptibility and permeability, Relation between **B, H, M**, Ferromagnetism, B-H curve and hysteresis.
Electromagnetic Induction: Faraday's Law, Lenz's Law, Self-inductance and mutual inductance, Reciprocity theorem, Energy stored in a magnetic field, Introduction to Maxwell's equations, Charge conservation and displacement current.

Texts/References:

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2^{nd} Edn.1981, McGraw-Hill
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D J Griffiths, 3rd Ed., 1998, Benjamin Cummings
4. Feynman Lectures Vol.2, R P Feynman, R B Leighton, M Sands, 2008, Pearson Education
5. Electricity and Magnetism, J H Fewkes and J Yarwood, Vol. I, 1991, Oxford Univ. Press

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PH 114-ELECTRICITY AND MAGNETISM LAB

Credits: 02 (0-0-4)

Course objective: *The laboratory content compliments the theoretical knowledge of Electricity and*

Magnetism and henceforth, gives hands-on experience. It also provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following:

1. Use a multimeter for measuring (i) Resistances, (ii) AC and DC Voltages, (iii) DC current, (iv) Capacitances, and (v) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx).
7. To determine self-inductance of a coil by Anderson's bridge.
8. To study response curve of a Series LCR circuit and determine its (i) Resonant frequency, (ii) Impedance at resonance, (iii) Quality factor Q and (iv) Band width.
9. To study the response curve of a parallel LCR circuit and determine its (i) Anti-resonant frequency and (ii) Quality factor Q.
10. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer.
11. Determine a high resistance by leakage method using Ballistic Galvanometer.
12. To determine self-inductance of a coil by Rayleigh's method.
13. To determine the mutual inductance of two coils by Absolute method.
14. To determine the specific resistance of a wire or unknown capacitance by Wien's bridge.
15. To determine the magnetic field along the axis of the current carrying coil and estimate the radius of coil using Tangent Galvanometer.
16. To study Hysteresis curve of a given ferromagnetic sample and determine magnetic susceptibility and permeability.
17. To study faraday's law and induced electromotive force (emf).
18. Calibration of a voltmeter/ammeter with the help of a potentiometer.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S Panigrahi and B Mallick, 2015, Cengage Learning

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PH 116-WAVES AND OPTICS

Credits: 04(4-0-0)

Course objectives: *This course begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. It also provides an in depth understanding of wave phenomena of light, namely, interference, diffraction and polarization with emphasis on practical applications of the same.*

Superposition of Harmonic oscillations: Simple harmonic motion (SHM), Superposition of two collinear oscillations having equal frequencies and different frequencies (Beats), Superposition of N collinear Harmonic Oscillations with (i) equal phase differences and (ii) equal frequency differences; Superposition of two perpendicular Harmonic Oscillations, Graphical and analytical methods, Lissajous figures with equal and unequal frequencies and their uses.
Wave Motion: Longitudinal and Transverse waves, Plane progressive (Travelling) waves, Wave equation, Standing (Stationary) waves in a String: Fixed and Free ends, Analytical treatment, Energy of vibrating string, Transfer of energy, Normal modes of stretched strings.
Wave Optics: Electromagnetic nature of light, Definition and properties of wave front, Huygens principle, Temporal and spatial coherence.
Interference: Division of amplitude and wavefront, Young's double slit experiment, Fresnel's biprism, Phase change on reflection: Stokes' treatment, Interference in thin films: parallel and wedge-shaped films, Fringes of

equal inclination (Haidinger fringes), Fringes of equal thickness (Fizeau fringes), Newton's rings: Measurement of wavelength and refractive index, Michelson Interferometer-(i) Idea of formation of fringes, (ii) Determination of wavelength, (iii) Wavelength difference, (iv) Refractive index, and (i) Visibility of fringes.
Diffraction: Fraunhofer diffraction: Single slit, Rectangular and circular aperture, resolving power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating, Fresnel diffraction: Fresnel's assumptions, Fresnel's half-period zones for plane wave, Explanation of rectilinear propagation of light, Theory of a Zone Plate: Multiple Foci of a Zone plate, Diffraction at a straight edge, a slit and a wire.
Polarization: Production of polarized light, Brewster's law, Polarizers, Malus Law, Double refraction, Polarization by double refraction, Nicol Prism, Quarter-Wave and Half-Wave plates, Detection and analysis of plane, circularly and elliptically polarized light, Wollaston and Rochon prisms, Rotatory Polarization: Optical Rotation, Biot's laws for rotatory polarization, Specific rotation, Laurent's half-shade polarimeter.

Texts/References:

1. Vibrations and Waves, A P French, 1st Edn., 2003, CRC press
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill
3. Fundamentals of Optics, F A Jenkins and H E White, 1981, McGraw-Hill
4. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press
5. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
6. The Physics of Waves and Oscillations, N K Bajaj, 1998, Tata McGraw Hill
7. Fundamental of Optics, A Kumar, H R Gulati and D R Khanna, 2011, R. Chand Publications
8. Optics, Eugene Hecht, 4thEdn., 2014, Pearson Education

PH 118-WAVES AND OPTICS LAB

Credits: 02 (0-0-4)

Course objectives: *The laboratory content compliments the theoretical knowledge of Waves and Optics and gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from the following:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To determine the frequency of AC mains using Sonometer.
4. To study Lissajous figures.
5. Familiarization with: Schuster's focusing, determination of angle of prism.
6. To determine refractive index of the material of a prism using sodium source.
7. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
8. To determine wavelength of sodium light using Fresnel biprism.
9. To determine wavelength of sodium light using Newton's rings.
10. To study interference and diffraction pattern with slits.
11. Focal length of a combination of two lenses using Nodal slide assembly.
12. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D P Khandelwal,1985, Vani Pub.

Semester III

PH 211-MATHEMATICAL PHYSICS-II

Credits: 04(4-0-0)

Course objectives: *The focus of the course is on applications in problems solving of interest to physicists. Students should be able to learn, understand and apply the concepts/formulas of Fourier transformation, differential equations, Bessel function, Beta and Gamma functions etc. to solve the mathematical problems.*

Fourier Series: Periodic functions, Orthogonality of sine and cosine functions, Dirichlet conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, Even and odd functions and their Fourier expansions, Application: Summing of Infinite series, Parseval identity and its application to summation of infinite series.

Some Special Integrals: Beta and Gamma functions and its properties, Transformation of Beta and Gamma function, Relation between Beta and Gamma function, Expression of Integrals in terms of Gamma functions.

Frobenius Method and Special Functions: Singular points of second order linear differential equations and their importance, Frobenius method and its applications to differential equations, Legendre, Bessel, Hermite and Laguerre differential equations, Properties of Legendre polynomials: Rodrigues formula, Generating function, Orthogonality, Simple recurrence relations, Expansion of function in a series of Legendre polynomials, Bessel functions of the first kind: Generating function, simple recurrence relations, Zeros of Bessel Functions [Jo(x) and J1(x)] and orthogonality.

Partial Differential Equations: Solutions using separation of variables: Laplace's equation in problems of rectangular geometry, Solution of wave equation for vibrational modes of a stretched string, rectangular and circular membranes, Solution of 1D heat flow equation (equation not to be derived).

Texts/References:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier
2. Fourier Analysis by M R Spiegel, 2004, Tata McGraw-Hill
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill
5. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
6. Mathematical methods for Scientists & Engineers, D A McQuarrie, 2003, Viva Books

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PH 213-MATHEMATICAL PHYSICS-II LAB

Credits: 02 (0-0-4)

Course objectives: *The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Computer Lab.*

At least two programs must be attempted from each programming section:

Introduction to Scilab Software

Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Introduction to plotting, 2D and 3D plotting,

Branching statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization.

User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays, Introduction to Scilab file processing, file opening and closing, Binary I/O functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.

Programming related to Numerical methods:

1. Curve fitting, Least square fit, Goodness of fit, standard deviation using Scilab:
2. Ohms law - calculate R, Hooke's law, Calculate Spring constant, Given Bessel's function at N points find its value at an intermediate point.
3. Solution of linear system of equations by Gauss elimination method and Gauss-Seidel method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen-value problems:
4. Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses)
5. Generation of special functions using user defined functions in Scilab:
6. Generating and plotting Legendre Polynomials, Generating and plotting Bessel function
7. Solution of ODE, First order differential equation Euler, modified Euler and Runge- Kutta (RK), second and fourth order methods, Second order differential equation, Fixed difference method,
8. First order differential equation: Radioactive decay Current in RC, LC circuits with DC source Newton's law of cooling, Classical equations of motion.
9. Second order differential equation: Harmonic oscillator (no friction), Damped Harmonic oscillator Forced harmonic oscillator, LCR circuits.
10. Partial differential equations, Wave equation, Heat equation, Poisson equation.

Texts/References:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Computational Physics, D Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
3. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rdEdn., Cambridge University Press
4. Getting started with Matlab, Rudra Pratap, 2010, Oxford University Press.
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, A V Wouwer, P Saucez, C V Fernández, 2014 Springer

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PH 215-THERMAL PHYSICS

Credits: 04(4-0-0)

Course objectives: *This course explains the relationship between macroscopic properties of the physical system in equilibrium. Students will be able to apply the Zero/First/Second laws and Maxwell thermodynamics equations for solving the numerical problems. It will also give basic knowledge of Heat engines, and exposure of Kinetic theory of gases, transport phenomenon involved in ideal gases, phase transitions and behavior of real gases.*

Introduction to Thermodynamics:

Zeroth and First Law of Thermodynamics: Extensive and intensive thermodynamic variables, Thermodynamic equilibrium, Zeroth law of thermodynamics and concept of temperature, Concept of work and heat, State functions, First law of thermodynamics and its differential form, Internal energy, First law and various processes, Applications of first law: General relation between C_P and C_V, Work done during Isothermal and Adiabatic processes.

Second Law of Thermodynamics: Reversible and irreversible process with examples, Conversion of work into heat and heat into work, Heat engines, Carnot's cycle, Carnot engine and efficiency, Refrigerator and coefficient of performance, 2nd law of thermodynamics: Kelvin-Planck and Clausius statements and their equivalence, Carnot's theorem.

Entropy: Concept of entropy, Clausius theorem, Clausius inequality, Second law of thermodynamics in terms of entropy, Entropy of a perfect gas, Principle of increase of entropy, Entropy changes in reversible and irreversible processes with examples, Entropy of the universe, Temperature–entropy diagrams for Carnot's cycle, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials: Thermodynamic potentials: Internal energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, their definitions, First and second order phase transitions with examples, Clausius Clapeyron equation and Ehrenfest equations.

Maxwell's Thermodynamic Relations: Derivation of Maxwell's thermodynamic relations and their applications, Maxwell's relations: (i) Clausius Clapeyron equation, (ii) value of C_p-C_v, (iii) Tds equations, (iv) Energy equations.

Kinetic Theory of Gases: Distribution of velocities: Maxwell-Boltzmann law of distribution of velocities in an Ideal gas and its experimental verification, Mean, RMS and most probable speeds, Degrees of freedom, Law of equipartition of energy (No proof required), Specific heats of gases.

Molecular Collisions: Mean Free Path, Collision probability, Estimation of Mean free path,

Real Gases: Behavior of real gases: deviations from the Ideal gas equation, Andrew's experiments on CO_2 gas, Virial equation, Critical constants, Continuity of liquid and gaseous state, Vapour and gas, Boyle temperature, van der Waal's equation of state for real gases, Values of critical constants, Joule-Thomson porous plug experiment. Joule-Thomson effect for real and van der Waal gases, Temperature of inversion, Joule-Thomson cooling.

Texts/References:

1. Heat and Thermodynamics, M W Zemansky, Richard Dittman, 1981, McGraw-Hill
2. A Treatise on Heat, Meghnad Saha and B N Srivastava, 1958, Indian Press
3. Thermal Physics, S Garg, R Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa
5. Heat Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, 1stEdn., 2008, S. Chand

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PH 217-THERMAL PHYSICS LAB

Credits: 02(0-0-4)

Course objectives: *The laboratory content develops experimental and data analysis skills through a wide range of experiment of Thermal Physics. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from the following:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with difference of Temperature of its two Junctions using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified range using Op-amp difference amplifier and to determine neutral temperature.
8. To determine the coefficient of linear expansion of given sample.
9. To determine the mechanical equivalent of heat (J) with the help of Joule's calorimeter.
10. To determine the coefficient of real expansion of a liquid (water) by up-thrust method.
11. To determine the thermal conductivity of rubber in the form of tube.
12. To determine the critical temperature and critical pressure of a gas.
13. To determine the value of γ (the ratio of two specific heats of gas) for air by Clement and Desorme's method.

14. To determine specific heat of a given liquid by method of cooling.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I Prakash & Ramakrishna, 11^{th} Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D P Khandelwal,1985, Vani Pub

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PH 219-DIGITAL SYSTEMS AND APPLICATIONS

Credits: 04 (4-0-0)

Course objectives: *This introduces the concept of Boolean algebra and the basic digital electronics of various logic Gates and memory elements. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.*

Digital Circuits: Difference between Analog and Digital circuits, Examples of linear and digital ICs, Binary numbers and conversion, BCD, Octal and hexadecimal numbers, AND, OR, NOT gates (using DTL and TTL), NAND, NOR, XOR, XNOR gates.

Boolean algebra: De Morgan's theorems, Simplification of logic circuit using Boolean Algebra, Minterms and Maxterms, Karnaugh's map, Minimization of logic circuits by Sum-of-Products and Product-of-Sums method.

Data processing and Arithmetic circuits: Binary addition, Binary subtraction using 2's complement, Half and full adders, Half and full subtractors, 4-bit binary Adder/Subtractor multiplexers, De-multiplexers, Decoders, Encoders.

Sequential Circuits: S-R and J-K Flip-Flops, Clocked (Level and Edge Triggered) Flip-Flops, D and T Flip-Flop, Preset and clear operations, Race-around conditions in J-K Flip-Flop, M/S J-K Flip-Flop.

Timers: IC 555: block diagram and applications: A stable multivibrator and Mono stable multivibrator.

Registers and Counters: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits), Ring counter, Asynchronous counters, Decade Counter, Synchronous Counter A/D and D/A converter.

Computer Organization: Input/Output Devices, Data storage (idea of RAM and ROM), Computer memory, Memory organization and addressing, Memory Interfacing, Memory map.

Intel 8085 Microprocessor Architecture: Main features of 8085, Block diagram, Components, Pin-out diagram, Buses, Registers, ALU, Memory, Stack memory, Timing and Control circuitry, Timing states, Instruction cycle, Timing diagram of MOV and MVI, Introduction to Assembly Language: 1 byte, 2 byte and 3-byte instructions.

Texts/References:

1. Fundamentals of Digital Circuits, Anand Kumar, 2^{nd}Edn, 2009, PHI Learning Pvt. Ltd.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
3. Digital Electronics, G K Kharate ,2010, Oxford University Press
4. Logic circuit design, Shimon P Vingron, 2012, Springer
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning
6. Digital Electronics, S K Mandal, 2010, 1^{st} edition, McGraw Hill
7. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall

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PH 221-DIGITAL SYSTEMS AND APPLICATIONS LAB

Credits: 02(0-0-4)

Course objectives: *The laboratory content develop experimental and data analysis skills through a wide range of experiment gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from section A and Section B

Section-A:

1. (a) To design a combinational logic system for a specified Truth Table.
   (b) To convert Boolean expression into logic circuit and design it using logic gate ICs.
   (c) To minimize a given logic circuit.
2. Half Adder, Full Adder and 4-bit binary Adder.
3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
5. To build JK Master-slave flip-flop using Flip-Flop ICs
6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.
9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B: **Programs using 8085 Microprocessor:**

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Use of CALL and RETURN Instruction.
6. Block data handling.

Texts/References:

1. Modern Digital Electronics, R P Jain, 4th Edition, 2010, Tata McGraw Hill
2. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller, 1994, Mc-Graw Hill
3. Microprocessor Architecture Programming and applications with 8085, R S Goankar, 2002, Prentice Hall
4. Microprocessor 8085: Architecture, Programming and interfacing, A Wadhwa, 2010, PHI Learning

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Semester IV

PH 212-MATHEMATICAL PHYSICS-III
Credits 04(4-0-0)

Course objectives: *This course introduces the mathematical methods essential for solving the advanced problems in physics. The knowledge of mathematical concepts and techniques would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering.*

Complex Analysis: Brief revision of complex numbers and their graphical representation, Euler's formula, De Moivre's theorem, Roots of complex numbers, Functions of complex variables, Analyticity and Cauchy-Riemann conditions, Examples of analytic functions, Singular functions: poles and branch points, order of singularity, branch cuts, Integration of a function of a complex variable, Cauchy's Inequality, Cauchy's Integral formula, Simply and multiply connected region, Laurent and Taylor's expansion, Residues and Residue theorem, Application in solving Definite Integrals.
Integrals Transforms: Fourier Transforms: Fourier Integral theorem (Statement only), Fourier transform,

Fourier sine and cosine transform, Examples, Fourier transform of single pulse, trigonometric, exponential, and Gaussian functions, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem, Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.), One dimensional wave equation.

Laplace Transforms: Laplace Transform (LT) of elementary functions, Properties of LT: Change of Scale theorem, Shifting theorem. LTs of 1st and 2nd order derivatives and Integrals of functions, Derivatives, and Integrals of LTs, LT of unit step function, Periodic functions, Convolution theorem, Inverse LT, Application of Laplace transforms to 2nd order differential equations: Coupled differential equations of 1st order, Solution of heat flow along semi-infinite bar using Laplace transform.

Dirac delta function: Definition and properties, Representation of Dirac delta function as a Fourier Integral, Laplace and Fourier transform of Dirac delta function.

Texts/References:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P Dennery and A Krzywicki, 1967, Dover Publications
3. Complex Variables, A S Fokas and M J Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A K Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J W Brown and R V Churchill, 7th Ed. 2003, Tata McGraw-Hill

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PH 214-MATHEMATICAL PHYSICS-III LAB

Credits 02 (0-0-4)

Course objectives: *This laboratory would introduce students with the basic knowledge of scientific programming languages and graphical analysis. Also, the students would be able to implement C++/C/Scilab simulations for common and scientific problems.*

C^{++}/C/Scilab based simulations experiments will be based on following Mathematical Physics problems:

1. Solve first order and second order differential equations.
2. Evaluate problems with Dirac Delta functions.
3. Evaluate the Fourier coefficients and find the Fourier Series of a given periodic function.
4. Frobenius method and evaluation of Special functions.
5. Evaluation of trigonometric functions. Given Bessel's function at N points and find its value at an intermediate point.
6. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
7. Calculation of least square fitting manually for a given data set and confirmation of least square fitting of data through computer program.
8. Application of Fast Fourier Transform

Texts/References:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P Dennery and A Krzywicki, 1967, Dover Publications
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A Vande Wouwer, P Saucez, C V Fernández. 2014 Springer ISBN: 978-3319067896
4. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rdEdn., Cambridge University Press
5. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

PH 216-ELEMENTS OF MODERN PHYSICS

Credits: 04 (4-0-0)

Course objectives: *This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. It also introduces basic concepts of nuclear physics.*

Theory of Radiation: Spectral distribution of Black Body radiation, Pure temperature dependence, Radiation pressure, Kirchhoff's law, Stefan-Boltzmann law: Thermodynamic proof, Wien's displacement law, Wien's distribution law, Rayleigh-Jean's law, Ultraviolet Catastrophe, Planck's quantum postulates, Planck's law of Blackbody radiation: experimental verification, Deduction of (i) Wien's Distribution law, (ii) Rayleigh-Jeans law, (iii) Stefan-Boltzmann law, (iv) Wien's Displacement law from Planck's law.

Inadequacy of classical Physics: Planck's quantum theory, Photo-electric effect and Compton scattering, de Broglie wavelength and matter waves, Wave-particle duality, Davisson-Germer experiment, Wave description of particles by wave packets, Group and Phase velocities and relation between them, Two Slit experiment with electrons, Probability, Wave amplitude and wave functions. Position measurement-gamma ray microscope, Heisenberg uncertainty principle, Energy-time uncertainty principle. Derivation from Wave Packets, Impossibility of a particle following a trajectory, Estimating minimum energy of a confined particle, Two slit interference experiment with photons, atoms and particles, linear superposition principle as a consequence,

Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus (using uncertainty principle), Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy.

Radioactivity: stability of the nucleus, Law of radioactive decay, Mean life and half-life, Alpha decay, Beta decay- energy released, spectrum and Pauli's prediction of neutrino, Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus, Fission and fusion-mass deficit, relativity and generation of energy, Fission- nature of fragments and emission of neutrons, Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions)

Texts/References:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J Griffith, 2005, Pearson Education.
4. Physics for Scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G Kaur and G R Pickrell, 2014, McGraw Hill
6. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
7. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

PH 218-ELEMENTS OF MODERN PHYSICS LAB

Credits 02 (0-0-4)

Course objectives: *This laboratory provides the theoretical knowledge of Modern Physics and gives hands-on experience. Students will learn how to measure different universal constants with several experiments. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from following:

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light.

3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (i) Magnetic focusing or (ii) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practical, Michael Nelson and Jon M Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11thEdn, 2011, Kitab Mahal

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PH 220-ANALOG SYSTEMS AND APPLICATIONS

Credits: 04 (4-0-0)

Course objectives: *This course explains about the physics of semiconductor p-n junction and devices, transistor biasing and stabilization circuits are explained. The concept of feedback in the amplifiers and oscillator circuits are also discussed in detail. This will also give an understanding of working principle of operational amplifiers, CRO and their applications.*

Semiconductor Diodes: p and n-type semiconductors, Energy level diagram, Conductivity and mobility, Concept of drift velocity, Barrier formation, Barrier potential, Current flow mechanism in forward and reverse biased diode.
Two-terminal Devices and their Applications: Half-wave and full-wave rectifiers, Ripple factor and rectification efficiency, Zener diode and Voltage regulation, Principle, Structure and characteristics of LED, Photodiode and solar cell, Qualitative idea of Schottky diode and Tunnel diode.
Bipolar Junction transistors: n-p-n and p-n-p transistors, I-V characteristics of CB and CE configurations, Current gains α and β and relations between them, DC load line and Q-point, Physical mechanism of current flow.
Amplifiers: Transistor biasing and stabilization, Fixed bias and voltage divider Bias, Two-port network, h-parameter equivalent circuit, Single-stage CE amplifier using hybrid model, Input and output impedance, Current, Voltage and power gains, Classification of class A, B and C amplifiers, Two stage RC-coupled amplifier and its frequency response.
Feedback and Oscillators: Positive and negative feedback, Effect of negative feedback on input impedance, Output impedance, Gain, Stability, Distortion and noise, Barkhausen's criterion for self-sustained oscillations, RC Phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators.

Operational Amplifiers: Characteristics of Op-Amp, Open-loop and closed-loop gain, Frequency response, CMRR, Slew rate and concept of virtual ground, Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Comparator, Zero crossing detector, Wein Bridge oscillator, Schmitt trigger, D/A resistive networks.

Texts/References:

1. Integrated Electronics, J Millman and C C Halkias, 1991, Tata Mc-Graw Hill
2. Electronics: Fundamentals and Applications, J D Ryder, 2004, Prentice Hall
3. Solid State Electronic Devices, B G Streetman & S K Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S Salivahanan & N S Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. Op-Amps and Linear Integrated Circuit, R A Gayakwad, 4th edition, 2000, Prentice Hall

6. Microelectronic circuits, A S Sedra, K C Smith, A N Chandorkar, 2014, 6thEdn., Oxford University Press
7. Microelectronic Devices & Circuits, David A Bell, 5th Edn.,2015, Oxford University Press

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PH 222-ANALOG SYSTEMS AND APPLICATIONS LAB
Credits: 02 (0-0-4)

Course objectives: *This laboratory provides a hands-on experiment based on PN junction diode, transistors, Op-amp, amplifiers etc. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from the following:

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To study the Colpitt's oscillator.
10. To design a digital to analog converter (DAC) of given specifications.
11. To study the analog to digital convertor (ADC) IC.
12. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
13. To design inverting amplifier using Op-amp (741,351) and study its frequency response
14. 15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
15. To study the zero-crossing detector and comparator
16. To add two dc voltages using Op-amp in inverting and non-inverting mode
17. To investigate the use of an op-amp as an Integrator.
18. To investigate the use of an op-amp as a Differentiator.

Texts/References:
1. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller, 1994, Mc-Graw Hill
2. Op-Amps and Linear Integrated Circuit, R A Gayakwad, 4th edition, 2000, Prentice Hall
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill
4. Electronic Devices & Circuit Theory, R L Boylestad & L D Nashelsky, 2009, Pearson

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Semester V

PH 311-QUANTUM MECHANICS AND APPLICATIONS
Credits: 04 (4-0-0)

Course objectives: *This course is an application of Schrodinger equation to various quantum mechanical problems. This gives fair idea of formulation of eigenvalues and eigen functions.*

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state, Properties of wave function, Interpretation of wave function, Probability and probability current densities in three dimensions, Conditions for physical acceptability of wave functions, Normalization and orthogonality condition, Linearity and Superposition principles, Eigenvalues and Eigen functions, Position, momentum and energy operators, commutator of position and momentum operators, Expectation values of position and momentum, Wave function of a free particle.

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigen values, expansion of an arbitrary wave function as a linear combination of energy eigen functions, General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states, Application to spread of Gaussian wave-packet for a free particle in one dimension, wave packets, Fourier transforms and momentum space wave function, eigen functions using Frobenius method, Hermite polynomials, ground state, zero point energy and uncertainty principle.

General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary condition and emergence of discrete energy levels, application to one-dimensional problem- square well potential, Quantum tunneling, Quantum mechanics of simple harmonic shapes of the probability densities for ground and first excited states, Orbital angular momentum quantum numbers l and m, s, p, d shells.

Quantum theory of hydrogen-like atoms: Time independent Schrodinger equation in spherical polar coordinates, separation of variables for second order partial differential equation, angular momentum operator and quantum numbers.

Symmetry in quantum mechanics: symmetric and anti- symmetric wave functions, identical particles, Pauli's exclusion principle.

Texts/References:

1. A Text book of Quantum Mechanics, P M Mathews and K Venkatesan, 2^{nd} Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2^{nd} Edn., 2002, Wiley
3. Quantum Mechanics, Leonard I. Schiff, 3^{rd} Edn. 2010, Tata McGraw Hill
4. Quantum Mechanics for Scientists and Engineers, D A B Miller, 2008, Cambridge University Press
5. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
6. Introduction to Quantum Mechanics, D J Griffith, 2^{nd} Ed. 2005, Pearson Education

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PH 313-QUANTUM MECHANICS LAB

Credits: 02 (0-0-4)

Course objectives: *This lab compliments the problem based on Quantum Mechanics using C++ programming language.*

Use of C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics:

1. To solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: Obtain the energy eigenvalues and plot the corresponding wavefunctions.
2. Solve the s-wave radial Schrodinger equation for an atom. Find the energy of the ground state of the atom and plot the corresponding wavefunction.
3. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

Laboratory based experiments (Optional):

4. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
5. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
6. Quantum efficiency of CCDs

Texts/References:

1. Schaum's outline of Programming with C++, J Hubbard, 20 00, McGraw-Hill Publication
2. An introduction to computational Physics, T Pang, 2^{nd} Edn., 2006, Cambridge Univ. Press
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer
4. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.

5. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rd Edn., Cambridge University Press

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PH 315-SOLID STATE PHYSICS

Credits: 04(4-0-0)

Course objectives: *This aims to provide a general introduction to theoretical and experimental topics in solid state physics. This course also elucidates the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials. It also explains the main features of the physics of electrons in solids, explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.*

Crystal Structure: Amorphous and crystalline materials, Lattice translation vectors, Lattice with a Basis, Space lattice, Basic symmetry operations, Symmetry elements, Unit cell and primitive lattice cell, Miller indices, Fundamental types of lattices (Bravais Lattices), Reciprocal lattice, Brillouin zones, Diffraction of X-rays by crystals, Bragg's law, Laue condition, Atomic scattering factor and Geometrical structure factor.
Elementary Lattice Dynamics: Lattice vibrations and phonons: Linear monoatomic and diatomic chains, Acoustical and optical phonons, Qualitative description of the phonon spectrum in solids, Dulong and Petit's law, Einstein and Debye theories of specific heat of solids (Qualitative discussion), T^3 law.
Electrons in Solids: Electrons in metals- Drude Model, Density of states, Elementary band theory: Kronig Penny model, Band Gap, Effective mass, mobility, Hall Effect (Metal and Semiconductor).
Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic materials, Classical Langevin theory of dia- and paramagnetic materials, Quantum mechanical treatment of Paramagnetism, Curie's law, Weiss's theory of ferromagnetism and ferromagnetic domains, Discussion on B-H curve, Hysteresis loss.
Dielectric Properties of Materials: Polarization, Local Electric Field at an atomElectric susceptibility, Polarizability, Clausius-Mosotti equation, Langevin-Debye equation. (Qualitative discussion)
Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Ferroelectric effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.
Superconductivity: Experimental results, Critical temperature, Critical magnetic field, Meissner effect, Type I and type II Superconductors, London's equation and Penetration depth, Isotope effect, Idea of BCS theory (No derivation).

Texts/References:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edn., 2004, Wiley India Pvt. Ltd
2. Elements of Solid-State Physics, J P Srivastava, 2nd Edn., 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N W Ashcroft and N D Mermin, 1976, Cengage Learning
5. Solid-state Physics, H Ibach and H Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Solid State Physics, M A Wahab, 2011, Narosa Publications

PH 317-SOLID STATE PHYSICS LAB

Credits: 02(0-0-4)

Course objectives: *The laboratory content compliments the theoretical knowledge of Solid-state physics and gives hands-on experience. Students will learn different kind of material and their nature by performing several experiments. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from the following:

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid and determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^{o}C) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field (Magneto-resistance).

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Elements of Solid-State Physics, J P Srivastava, 2nd Ed., 2006, Prentice-Hall of India

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Semester VI

PH 312-ELECTROMAGNETIC THEORY

Credits: 04(4-0-0)

Course objectives: *The course covers Maxwell's equations, propagation of electromagnetic waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production, and detection of different types of polarized electromagnetic waves, general information as waveguides and fibre optics. Students will be able to apply the laws/formulas to solve the numerical problems of quarter/half wave plates, internal reflection, numerical aperture etc.*

Maxwell Equations: Review of Maxwell's equations, Displacement current, Vector and Scalar potentials, Gauge transformations: Lorentz and Coulomb gauge, Wave equations, Plane waves in dielectric media, Poynting theorem and Poynting vector, Electromagnetic (EM) energy density, Physical concept of electromagnetic field energy density, Momentum density and angular momentum density.

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance, Propagation through conducting media, relaxation time, skin depth, Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media, Reflection and Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection and Refraction, Fresnel's Formulae for perpendicular and parallel polarization cases, Brewster's law, Reflection and Transmission coefficients, Total internal reflection, evanescent waves, Metallic reflection (normal Incidence).

Transmission Lines: Transmission line parameters, Equations, Input impedance, SWR, Power, Smith chart.

Wave Guides: Rectangular wave guides, TE, TM and TEM mode wave propagation, Power transmission and attenuation.

Antennas: Introduction to Antennas, Antenna characteristics.

Optical Fibers: Principle of light transmission in optical fiber, classification of fibers – step index and graded index, single mode and multimode. Numerical aperture and acceptance angle, applications.

Texts/References:

1. Introduction to Electrodynamics, D J Griffiths, 3rd Ed., 1998, Benjamin Cummings
2. Electromagnetic Field and Waves, P Lorrain and D Corson, 2nd Ed., 2003, CBS Publisher
3. Elements of Electromagnetics, M N O. Sadiku, 2001, Oxford University Press
4. Fundamentals of Electromagnetics, M A W Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R S Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill
7. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill
8. Electromagnetic field theory fundamentals, B Guru and H Hiziroglu, 2015, Cambridge University Press
9. Classical Electrodynamics, J D Jackson, 3rdEdn., 2010, Wiley
10. Principle of Optics, M Born and E Wolf, 6thEdn., 1980, Pergamon Press
11. Optics, A Ghatak, 5thEdn., 2012, Tata McGraw Hill Education

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PH 314-ELECTROMAGNETIC THEORY LAB

Credits: 02(0-0-4)

Course objectives: *The laboratory content compliments the theoretical knowledge of Electromagnetic Theory and gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 08 experiments from the following:

1. To study dependence of radiation on angle for a simple dipole antenna.
2. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
3. To study the reflection, refraction of microwaves.
4. To study Polarization and double slit interference in microwaves.
5. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
6. To determine the refractive Index of (i) glass and (ii) a liquid by total internal reflection using a Gaussian eyepiece.
7. To verify the Stefan`s law of radiation and to determine Stefan's constant.
8. To determine Boltzmann constant using V-I characteristics of PN junction diode.
9. To find Numerical Aperture of an Optical Fibre.
10. To verify the law of Malus for plane polarized light.
11. To determine the specific rotation of sugar solution using Polarimeter.
12. To verify Brewster's law and to find the Brewster's angle.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Electromagnetic Field Theory for Engineers and Physicists, G Lehner, 2010, Springer

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PH 316-STATISTICAL MECHANICS

Credits: 04(4-0-0)

Course objectives: *This course provides elementary and applied Statistical Mechanics for exploring the Bose-*

Einstein statics, Fermi-Dirac statics, Relativistic Fermi-Gas, Black body radiation, Stefan-Boltzmann law etc. The objective of this course work is to introduce and apply the techniques of Statistical Mechanics which have applications in; Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry etc.

Classical Statistics: Macrostate and Microstate, Phase space, Elementary concept of ensemble, Entropy and thermodynamic probability, Maxwell-Boltzmann distribution law, Partition function, Thermodynamic Functions of an ideal gas, Classical entropy expression, Gibbs paradox, Sackur-Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its limitations, Thermodynamic functions of a two-energy levels system, Concept of negative temperature.
Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly degenerate Bose gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and thermodynamic functions of photon gas, Bose derivation of Planck's law.
Fermi-Dirac Statistics: Fermi-Dirac distribution law, Thermodynamic functions of a completely and strongly degenerate Fermi gas, Fermi energy, Electron gas in a metal, Specific heat of metals, Relativistic Fermi gas, White Dwarf stars, Chandrasekhar Mass Limit.
Theory of Radiation: Properties of thermal radiation, Blackbody radiation, Pure temperature dependence, Radiation pressure, Kirchhoff's law, Stefan-Boltzmann law: Thermodynamic proof, Wien's displacement law, Wien's distribution law, Saha's Ionization formula, Rayleigh-Jean's law, Ultraviolet Catastrophe, Spectral distribution of Black Body radiation, Planck's quantum postulates, Planck's law of Blackbody radiation: experimental verification, Deduction of (i) Wien's Distribution law, (ii) Rayleigh-Jeans law, (iii) Stefan-Boltzmann law, (iv) Wien's Displacement law from Planck's law.

Texts/References:

1. Statistical Mechanics, R K Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press
2. Statistical Physics, Berkeley Physics Course, F Reif, 2008, Tata McGraw-Hill
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W Sears and Gerhard L Salinger, 1986, Narosa
4. An Introduction to Statistical Mechanics and Thermodynamics, R H Swendsen, 2012, Oxford Univ. Press
5. Statistical Physics , F. Mandl, 2ndEdn., 2003, Wiley
6. Introductory Statistical Mechanics, R Bowley and M Sanchez, 2nd Edn., 2007, Oxford Univ. Press

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PH 318-STATISTICAL MECHANICS LAB
Credits: 02 (0-0-4)

Course objectives: *The laboratory content develops experimental and data analysis skills through a wide range of experiment of Statistical Mechanics. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative data analysis skills of the students.*

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   e) Computation and study of mean molecular speed and its dependence on particle mass
   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function Z(E) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   a) Study of how Z(E), average energy <E>, energy fluctuation ΔE, C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   b) Ratios of occupation numbers of various states for the systems considered above
   c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at large and small wavelength for a given temperature.
4. Plot specific heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution
6. Plot the distribution of particles w.r.t. energy (dN/dE versus E) for
   a) Relativistic and non-relativistic bosons both at high and low temperature.
   b) Relativistic and non-relativistic fermions both at high and low temperature.

Texts/References:

1. Elementary Numerical Analysis, K E Atkinson, 3rd Edn . 2007, Wiley India Edition
2. Statistical Mechanics, R K Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press
3. Introduction to Modern Statistical Mechanics, D Chandler, 1987, Oxford University Press,
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W Sears and Gerhard L Salinger, 1986, Narosa
5. Modern Thermodynamics with Statistical Mechanics, Carl S Helrich, 2009, Springer
6. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010

Semester VII

PH411 SEMICONDUCTOR PHYSICS AND DEVICES

Credits-04 (4-0-0)

Course objectives: *This course aims theoretical study of semiconductor physics, fabrication techniques of solid-state devices and their characteristics. This course includes topics on charge carriers and their transport, fabrication of P-N junction diodes and its characteristics, band structure and its engineering, junctions, quantum theory of semiconductors and semiconductor optoelectronic devices.*

Bonding Forces and Energy Bands in Solids, Charge Carriers in Semiconductors, Carrier Concentrations, Drift of Carriers in Electric and Magnetic Fields, Excess carriers in Semiconductors, Fabrication of P-N Junctions, Forward and Reverse Biased Junctions, Reverse-Bias Breakdown, Transient and A-C Conditions, Band Structure Engineering, Metal-Semiconductor Junctions, Semiconductor Hetero-junctions, Photodiode, LED, Semiconductor Laser, Solar Cells, Physics of Bipolar Devices, Hot Electron Devices, Fundamentals of MOS and Field effect Devices, Review of Quantum theory of Semiconductors, Electrons and Holes in Quantum-Wells, Wires and Dots, Resonant Tunnel Diode.
Semiconductor Optoelectronics: Interactions of photons with semiconductors, semiconductor-based photon sources, light emitting diodes (LEDs), semiconductor-laser amplifiers, semiconductor injection lasers, semiconductor-based absorbers, photodetectors (visible, infrared & THz), photoconductors, photodiodes, avalanche photodiodes, responsivity, dark current, photocurrent and noise in photodetectors, solar cells.

Texts/References:

1. Rolf Enderlein, Norman J Horing, **“Fundamentals of Semiconductor Physics and Devices”**, World Scientific (**1997**).
2. Ben Garland Streetman, Sanjay Kumar Banerjee, **“Solid State Electronic Devices”**, Pearson Prentice Hall **(2006).**
3. S. M. Sze, **“Semiconductor Devices: Physics and Technology”**, 2^{nd} Ed., John Wiley & Sons **(1969).**
4. M.S.Tyagi, **“Introduction to semiconductor, materials and devices”,** John Wiley & Sons **(2008).**

PH413 SEMICONDUCTOR PHYSICS LABORATORY

Credits-02 (0-0-2)

1. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^{o}C) by four-probe method.
2. To determine the energy band gap of semiconductor using a thermistor.
3. To determine the Hall coefficient of a semiconductor sample using Hall apparatus.
4. To study the V-I characteristics of a PN junction diode and a Zener diode.
5. To study the V-I and P-I characteristics of LED and find its external quantum efficiency.
6. To study the characteristics of a Tunnel Diode.
7. To study the V-I & P-I curves of a solar cell and find maximum power point & efficiency.
8. To study the characteristics of a Bipolar Junction Transistor in CE and CB configuration.
9. To study the characteristics of a Junction Field Effect Transistor (JFET).
10. To study the characteristics of a MOSFET.

PH415-RESEARCH METHODOLOGY IN PHYSICS

Credits-04 (4-0-0)

Course objectives: *This course provides a rigorous foundation in quantitative research methodologies, focusing on measurement, error analysis, probability distributions, and data analysis. It equips students with the essential tools for conducting precise and reliable research, emphasizing the interplay between theoretical frameworks and practical applications. Students will also develop a strong understanding of research design, ethics, and literature review, enabling them to construct well-structured and impactful research projects.*

Measurements, probability distributions, error analysis: Measuring Errors, accuracy and Precision, systematic errors, Random errors, Significant figures and Round off, Uncertainties, Parent and Sample Distributions, Mean, median and mode, Standard Deviation of Distributions.
Probability Distributions: Binomial Distributions, Poisson distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution.
Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Specific Error Formulas with examples, Numerical Errors, Conditioning and Stability, Convergence of Iterative Processes
Research theory: Research basics, Research theory, Structuring the research project, Research ethics, Finding and reviewing the literature. Selection of a research Problem, Necessity of Defining the Problem, Research Design: Meaning of Research Design.
Data collections: Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools. Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques. Collection of Primary Data, Observation Method, Collection of Data through Schedules.
Data analysis: Processing and Analysis of Data: Processing Operations, Some Problems in Processing.

Text/references:

1. Taylor, J. R. (1997). An introduction to error analysis: The study of uncertainties in physical measurements. University Science Books.

2. Bevington, P. R., & Robinson, D. K. (2003). Data reduction and error analysis for the physical sciences. McGraw-Hill.
3. Bryman, A. (2016). Social research methods. Oxford university press.

PH421 MINOR PROJECT
Credit-5 (0-0-4)

Course Objective: *This minor project aims to provide students with the opportunity to conduct an in-depth exploration of a specific physics topic of their choice, fostering their ability to effectively gather and synthesize relevant information from diverse sources. Students will be trained in the professional presentation of scientific topics, both in written and oral formats, to a scientific audience, while also cultivating a collaborative learning environment where they can discuss, share, and communicate scientific ideas with peers and faculty. Through literature review, students will identify research problems and formulate preliminary research ideas for their future major project, with a focus on societal benefit, ensuring regular interaction with their project advisors to promote continuous progress and guidance.*

Course Outcomes:
Upon successful completion of this seminar, students will be able to:
- *Demonstrate comprehensive understanding of a chosen physics topic.*
- *Conduct effective literature surveys and synthesize information.*
- *Produce a well-structured, professional project report.*
- *Deliver a clear, engaging oral presentation.*
- *Participate in discussions and share research ideas.*
- *Identify research problems and formulate relevant ideas.*
- *Maintain consistent project progress with advisor's interaction.*

Course Structure:
This 4-credit project will consist of weekly meetings focused on:
- Student presentations of selected research articles.
- Discussions of current research trends and debates.
- Presentations by guest speakers (when possible).
- Critical analysis of research methodologies and findings.

PH423-Institutional/ Laboratory visit
Credit-01 (0-0-1)

Course Objective: *The objective of the course is to provide students with firsthand exposure to real-world research and development environments through guided visits to relevant institutions and laboratories. The course aims to bridge the gap between theoretical knowledge and practical application, allowing students to observe cutting-edge research, interact with professionals, and gain insights into diverse career pathways. Through structured visits and post-visit reflections, students will develop a deeper understanding of the research process and its societal impact.*

Course Outcomes: *Upon successful completion of this course, students will be able to:*
- *Gain firsthand experience with research and development activities in institutional or laboratory settings.*
- *Observe and analyze the practical application of theoretical concepts.*
- *Interact with researchers and professionals in their field of interest.*
- *Develop an understanding of the diverse career pathways available in research and related fields.*
- *Reflect critically on the research process and its implications.*

Course Structure:

This 1-credit course will consist of:

- Pre-Visit Briefings: Introductory sessions to prepare students for each visit, including background information and objectives.
- Guided Institutional/Lab Visits: Structured tours and presentations at selected institutions or laboratories.
- Post-Visit Reflection Sessions: Discussions and written assignments to analyze and synthesize the experiences.

Semester VIII (Course Work)

PH412- ATOMIC AND MOLECULER PHYSICS

Credits: 4 (4-0-0)

Course objectives: *To increase the level of understanding of students about the various spectra of atoms, molecules and the use of electromagnetic radiation in understanding the tiny particles and the whole universe, they can enhance the understanding of interaction of light with matter which can be used to study various properties of different kinds of materials.*

Basics of Atomic Physics: Atomic models: Thomson's, Rutherford's (Brief introduction), Spectra of Hydrogen (H) atom, Bohr's and Sommer field's model, Quantum states of an electron in an atom, Spectra of He, Spectra of alkali metals.

Atoms in electric and magnetic fields: Orbital magnetic dipole moment: Electron's orbital angular momentum, Gyromagnetic ratio, Lande's g-factor and Bohr's magneton; Larmor's theorem, Space quantization, Electron spin and spin angular momentum, Stern-Garlach experiment, Vector atom models, L-S and J-J coupling, Electron magnetic moment and magnetic energy Zeeman effect: Normal and anomalous Zeeman effect, Paschen back and Stark effect (Qualitative discussion only).

Molecular Spectroscopy: Rotational and vibrational spectra of diatomic molecule, Electronic spectra, Franck-Condon principle. Electron spin and nuclear magnetic resonance spectroscopy, Raman Effect: Quantum Theory of Raman effect, Characteristics of Raman lines, Stoke's and anti-Stoke's lines, Applications of Raman effect, Complimentary character of Raman and infra- red spectra.

LASER: Introduction, Components of a Laser, Absorption, Spontaneous emission, Stimulated emission, Einstein's coefficients (A and B), Optical pumping and population inversion, Metastable states, Three-level Laser (Ruby Laser) and Four-level Laser (He-Ne Laser), Applications.

Texts/References:

1. Concepts of Modern Physics by Arthur Beiser, McGraw-Hill Book Company.
2. Atomic and Molecular Spectra: Laser by Raj Kumar, Kedar Nath Ram Nath, Delhi
3. Atomic Physics by J. B. Rajam, S. Chand and Company, Delhi.
4. Atomic Physics by J. H. Fewkes, and John Yarwood, Vol. II, Oxford University Press.
5. Elements of Spectroscopy by Gupta-Kumar-Sharma, Pragati Prakashan, Meerut.

PH414- NUCLEAR AND PARTICLE PHYSICS

Credits-04 (4-0-0)

Course objectives:

- *The objective of the course is to impart the understanding of the sub atomic particles and their properties.*
- *It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application.*
- *The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.*

General Properties of Nuclei: Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density, binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moment.
Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nuclear separation energies, Fermi gas model, Shell model: concept of magic numbers, evidence for nuclear shell structure and the basic assumption of shell model.
Radioactivity: Radioactive decay processes- alpha, beta and gamma decays, Geiger-Nuttal law, internal conversion.
Nuclear Reactions: : Reactions induced by neutron, proton, alpha particles, beta particles and gamma radiation, reactions at ultra-high energies, theory of compound nucleus formation and its limitations, Nuclear Fission and Fusion.
Accelerators & Detectors: Van de Graff accelerator, cyclotron, betatron, synchrotron, Geiger Muller counter, scintillation counter.
Particle Physics: Particle interactions, types of particles and its families, Conservation Laws (charge, spin, parity, isospin, strangeness, etc.), Gall-Mann-Nishijima equation, SU (2) and SU (3) symmetries (Boson octet, Baryon octet and Baryon decuplet), concept of quark model, color quantum number and gluons, Weight diagrams.

Texts/References:

1. Nuclear Physics by S. N. Ghoshal, First edition, 2010, S. Chand Publication,
2. Nuclear Physics by D. C. Tayal, Himalaya Publishing House,
3. Concepts of Nuclear Physics by Bemard L. Cohan, 1974, Tata McGraw Hill Publication,
4. Introductory Nuclear Physics by Kenneth S. Krane, 2008, Wiley-India Publication,
5. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw Hill Education,
6. Radiation Detection and measurement, G. F. Knoll, 2010, John Wiley and amp sons,
7. Technique for Nuclear and Particle Physics experiments by William R. Leo, 1994, Springer,
8. Introduction to Modern Physics, Mani and Mehta, 1990, Affiliated East-West Press,
9. Introduction to elementary particles, David J. Griffith, 2008, Wiley
10. Modern Physics, Serway, Moses and Moyer, 2012, CERGAGE LEARNING,

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PH426-Literary Project/ MOOC
Credit-04 (0-0-4)

This unique 4-credit course invites physics students to explore the intersection of scientific inquiry and literary expression. Students will develop and execute a significant literary project that integrates their understanding of physics concepts with creative storytelling, critical analysis, or hybrid forms, writing a review article or book chapter. This course aims to foster interdisciplinary thinking, enhance communication skills, and cultivate a deeper appreciation for the narrative power of science. Students will engage in rigorous research, creative writing, and critical reflection, culminating in a substantial literary project that bridges the gap between the scientific and literary realms.

Semester VIII (Project/ Dissertation)

PH 428-RESEARCH PROJECT/DISSERTATION

Credits: 16

It is a 16-credit course where students will prepare a written project report (in a specified format) to be submitted in the school and / or GBU Library and to be presented to the seminar committee.

1. Dissertation involves project work with the intention of exposing the student to research/development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

2. The objective of the project may be summarized as: (i) To prepare the student for deep and detailed exploration of a selected topic of interest, (ii) To prepare the student for collecting relevant data through array of available resources e.g. published books, monograms, scientific journals, online/web material, scientific magazines etc., (iii) To prepare the student for presenting a scientific topic, subject to the scientific community in a professional way, (iv) To cultivate the habit of discussing, sharing and communicating the ideas with the scientific community, (v) Final completion of a project based on experimental/simulation/theory/fabrication or characterization etc. (vi) To promote the students to write research papers based on the outcome of the project and present the results in national/international conferences.

3. Student must interact on day-to-day basis with the project advisor and should report his/her progress regularly.

4. The dissertation report should be of around 30 pages. It must have minimum three chapters namely (1) Introduction, (2) the main work including derivations / experimentation and Results, and (3) Discussion and Conclusion. At the end, adequate references must be included. Plagiarism should be avoided by the student and this should be checked by the supervisor.

Skill Enhancement Courses (SEC): Credit-03

SEC-1

PH119: INTRODUCTORY MATLAB PROGRAMMING

Credits: 3(2-0-1)

Course Objectives:

1. *To learn features of MATLAB as a programming tool.*
2. *To promote new teaching model that will help to develop programming skills and technique to solve mathematical problems.*
3. *To understand MATLAB graphic feature and its applications.*

MATLAB Basics – Introduction to various MATLAB windows, Variables, Numbers, Operators, Expressions, Input and output; **One and multidimensional Arrays** – Vector and matrix operations, Element-by-element operations, polynomial operations using arrays; Built-in Functions, User-defined functions; 2D plotting functions, Subplots and Overlay plots, Special Plot types, 3D plots; **Files and File Management** – Import/Export; Programming techniques: Design and development of program through algorithm and flowchart, Script file and function file, Saving and executing a program, Debugging; Relational and Logical operators, Conditional statements, Loops; Computer algebra and Symbolic Math Toolbox.

Texts/References:

1. Rudra Pratap, "Getting started with MATLAB", 7th Ed. (2019) Oxford University Press.
2. Amos Gilat, "MATLAB an introduction with applications", 3rd Ed. (2008), John Wiley & Sons.
3. Brian R. Hunt, Ronald L. Lipsman, "A Guide to MATLAB - for Beginners and Experienced Users", 2nd Ed., Jonathan M. Rosenberg, Cambridge University Press, (2006).
4. Web resource: www.mathworks.com.

PH121 - INTRODUCTION TO SciLab

Credits: 3(2-0-1)

Course objectives:

1. *To learn features of SciLab as a programming tool.*
2. *To promote new teaching model that will help to develop programming skills and technique to solve mathematical problems.*
3. *To understand SciLab graphic feature and its applications.*

Module I: Introduction to SciLab

Downloading and installing Scilab; Introduction to Scilab, mathematical operators, row vectors, column vectors, matrices, special matrices, plots, commands, manipulating command line, comments, variables in memory, functions, locate and display functions, function diary, help, menu, toolboxes.

Module II: Scalars and Vectors

Initializing vectors in scilab, Vectors: mathematical operators, relational operators, logical operators, built in logical functions, elementary mathematical functions, mathematical functions on scalars, complex numbers, trigonometric functions.

Module III: Matrices

Arithmetic operators for matrices, element wise arithmetic, basic matrix processing: transpose, trace, determinant, eigen value, matrices with various data types: constants, characters, strings, Boolean, polynomials; basic matrix operations.

Module IV: Programming in SciLab

Variables and variables names, assignment statements, arithmetic, relational and logical operators, input and output, flow control, branching, conditional statements, if/else if statement, select-case statements, for loop, nesting of loops, while loop, break and continue, handling matrices with loop, scripts, functions, user defined functions, special functions commands.

Module V: Polynomials

Creating polynomials, basic polynomial commands, finding roots of a polynomial, polynomial arithmetic, handling polynomials.

Module VI: Graphic Output

Graphic commands, 2D Plotting, plot commands, plot specifiers, command Plot2d, command Plot2d2, Plot2d3, Histplot, Matplot, Grayplot, 3D Plotting, commands: plot3d, plot3d1, contour, Hist 3D, Other graphic primitives

Texts/References:

1. Scilab by H Ramchandran and A S Nair, S Chand
2. Programming in Scilab by R Goyal and M Dhingra, Narosa Publishing
3. Introduction to Scilab for Engineers and Scientists, S Nagar, Apress
4. Basic Programming Concepts of SCILAB by Dr Devendra Chouhan and Dr Uday Dolas
5. Programming in Scilab 4.1 by Vinu V Das
6. Computing in Scilab by Chetana Jain

SEC-2

PH120- INTRODUCTION TO OFFICE AUTOMATION AND LaTeX

Credits: 3(2-0-1)

Course objectives: *To provide an in-depth training in use of office automation, basic internet tools and scientific word processing in LaTeX.*

Course outcomes: Students will have achieved the ability to:

- *Make documents, spreadsheets, make small presentations and would be acquainted with internet.*
- *Acquire the proficiency in effectively using the Windows and the LINUX operating system and in using the LaTeX software for wring a text file.*
- *Use the LaTeX software in writing articles and papers which include mathematical equations and diagrams.*

Introduction to Computer Fundamentals: Computer fundamentals, operating system, Internet and web browsers, Introduction to Boolean algebra.

MS Word: Shortcut Bars, Menu bar, Task bar, Status bar, Toolbar, Manipulating Images, Charts, Hyper Link, Shortcut keys, Document creation, Paragraph formatting, Header and Footer, Tables, Mail Merge, Spell check, File Operations– Cut, Copy and Paste, Drag and Drop, Undo, Redo, Find and Replace, Auto correct.

MS Excel: Work sheet, Insert, delete, Resize of the Columns and Rows, Views of Worksheets, Usage of Formula and Calculation, Different Charts, Tables and Formatting, plotting graphs, Query, Macros, Formatting Spreadsheets, Sorting, Usage of Formula, Formatting text, Spell check and Error checking.

MS PowerPoint: Creating a presentation, Formatting a presentation, Adding effects to the presentation, Reusability and Templates of the presentation, hyperlink, Different views of Slides, Tables, Columns and Lists, Adding Graphics, Sounds and Movies of a Slide, Objects, Design, Effects, Animation, Multimedia in PPT, Slide show, Transition and Timings, Clipart and Pictures, File management.

Introduction to LaTeX: Installation of MikeTeX, Online Overleaf access, TEX and its offspring, Creating a

Title, Sections, Command names, and arguments, Labelling Table of Contents, Font Effects, Coloured Text, Font Sizes, Comments & Spacing Special Characters, Line breaking. **Scientific Writing in LaTeX:** Lists, Tables, Figures – Inserting figures, List of figures, Equations: Inserting Equations and Mathematical Symbols, Inserting References: Inserting the Bibliography Styles, Technical Report: Writing Thesis/project/report, Classes: article, book, report, slides, Making an index and glossary.

Texts/References:

1. "Computer Fundamentals" by P.K. Sinha and Priti Sinha
2. "How the Internet Works" by Preston Gralla
3. "Microsoft Office 365: Step by Step" by Joan Lambert
4. "Microsoft Office 2019/2021 Bible" series (Word, Excel, PowerPoint)
5. "The LaTeX Companion" by Michel Goossens, Frank Mittelbach, and Alexander Samarin
6. "A Short Introduction to LaTeX" by Tobias Oetiker
7. "LaTeX for Complete Novices" by Nicola L.C. Talbot
8. "LaTeX and Friends" by Marc van Dongen

PH122- INTRODUCTION TO PYTHON

Credits: 3(2-0-1)

Course objectives:

- *To understand the basic principles of computers and programming languages.*
- *To gain practical knowledge by applying theses computational tools to correlate with the theoretical problems and to understand the measurements technology, usage of new instruments and real time applications in engineering studies.*

Course outcomes:

On Completion of this course, students are able to

- *Understand basics of binary computation*
- *Understand the programming basics (operations, control structures, data types, etc.)*
- *Readily use the Python programming language*
- *Apply various data types and control structure*
- *Gain knowledge of new concept in the solution of practical oriented problems and to understand more deep knowledge about the solution to theoretical problems.*

Introduction to Programming in Python

Introduction to Programming in Python**:** Features of Python, Python environment set up: Installing Python, Running Python, Python Documentation, Structure of a Python Program**,** Functions, Interpreter cell, Identifiers and keywords, Literals, Strings, Basic operators (Arithmatic operator, Relational operator, Logical or Boolean operator, Assignment operator, Bitwise operator).

Building blocks of Python

Standard libraries in Pythons, Notion of class, object and method.

Creating Python Programs:

Input and output Statements, Control statements: branching, looping, Conditionals and Loops: if statement, else Statement, elif Statement, while Statement, for Statement break Statement, continue Statement, pass Statement, Functions: Built-in Functions, User defined functions: Defining a Function, Calling a Function, Various Function Arguments, Exit function, break, continue and pass, mutable and immutable structures, Testing and debugging a program.

Built-in data structures

Strings, lists, Sets, Tuples and Dictionary and associated operations. Basic searching and sorting methods using iteration and recursion.

Visualization using 2D and 3D graphics

Visualization using graphical objects like point, line, Histogram, Trigonometric curves (Sine, cosine etc.), 3D objects.

Texts/References:

1. Core Python Programming Wesley J. Chun Publisher: Prentice Hall PTR First Edition.
2. T. Budd, Exploring Python, TMH, 1st Ed, 2011
3. Python Tutorial/Documentation www.python.or 2010
4. Allen Downey, Jeffrey Elkner, Chris Meyers, How to think like a computer scientist: learning with Python, Freely available online.2015
5. Web Resource: http://interactivepython.org/courselib/static/pythonds

SEC-3

PH223- FUNDAMENTALS OF DIGITAL IMAGE PROCESSING

Credits: 3 (2-0-1)

Course objectives: *The course is intended for undergraduate students from any discipline motivated to understand the scientific aspects of image processing to explore the ever-expanding applications of the same. Objective of this course is to make students able to:*

- *To develop theoretical foundations of digital image processing.*
- *To learn techniques of image manipulation including image acquisition and preprocessing.*
- *To learn the use of an image processing tool and apply to process images for various practical applications.*

Image sensing and acquisition, Image sampling and quantization, Neighborhood of a pixel: connectivity, regions and boundaries, distance measures.
Spatial domain image processing: Gray level transformations, Histogram processing, Image enhancement using arithmetic/ logic operations: smoothing and sharpening of images, Edge detection.
Frequency domain image processing: 1D and 2D Discrete Fourier Transformation and its inverse, Filtering in frequency domain, Correspondence between spatial and frequency domain processing, Convolution and correlation, Fast Fourier Transform. (7 Lectures)
Image restoration: Noise model of images, Restoration in presence of noise in spatial and frequency domain.
Colour Image Processing: Colour models, Colour transformations, Colour complements, Colour slicing, Tone and colour corrections, Histogram processing.

Texts/References:

1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Pearson,
2. William K Pratt, “Digital Image Processing”, Wiley.
3. Anil K. Jain, “Fundamentals of Digital Image Processing”, Pearson.

PH225- INTRODUCTION TO MACHINE LEARNING

Credits: 3(2-0-1)

Course objectives: *Machine Learning is a sub-field of Artificial Intelligence which is growing very fast with numerous application potentials. This course introduces students to the basic concepts and techniques of Machine Learning. The objective of this course is to develop the skills required for Machine Learning Technologies using computer software. The student will learn to formulate and solve problems such as regression and classification using machine learning algorithms.*

Prerequisite: Knowledge of Python.

Introduction to Artificial Intelligence (AI) and scope of Machine Learning (ML); Artificial Neural Network (ANN): Activation functions, Training Methods, Supervised and Unsupervised learning; Algorithms for ML: Linear Regression, Decision Trees, K-nearest neighbour algorithms, Logistic Regression, Support Vector Machine (SVM), Nonlinear SVM and kernel functions; Advanced learning methods: K-means clustering, Reinforcement Learning, Deep Learning (Introduction only); Fuzzy Logic and Genetic Algorithm.

Texts/References:

1. Oliver Theobald, "Machine Learning for Absolute Beginners", Online Edition.
2. M. Pradhan, U. Dinesh Kumar, "Machine Learning Using Python", Wiley.
3. A. Burkov, "A hundred-page machine learning book", A. Burkov

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PH417- INTRODUCTION TO CLOUD COMPUTING

Credits: 3(2-0-1)

Course objectives: *This course introduces the fundamental concepts of cloud computing. The course will cover the basic principles, models, and services of cloud computing, its benefits, and applications.*

Basics of Computing Models: Basic characteristics of cloud computing, Evolution of cloud computing, Comparison with traditional computing models, Benefits and challenges of cloud computing, Cloud Computing Models; Service Models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS); Deployment Models: Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud.

Cloud architecture and services: Overview of cloud architecture, Virtualization technology, Storage and network considerations; Cloud services; Compute Services: Virtual Machines, Containers; Storage Services: Object Storage, File Storage, Block Storage; Database Services: SQL vs NoSQL, Managed Databases.

Cloud Security and Legal Compliance: Security challenges in cloud computing; Data privacy and protection; Identity and access management; Regulatory compliance (GDPR, HIPAA, etc.), Legal considerations in cloud computing, Service Level Agreements (SLAs) and their importance.

Cost Management: Cost benefits of cloud computing; Capital expenditure vs operational expenditure; Cost models and billing in cloud computing; Resource allocation and scaling; Cost optimization techniques; Monitoring and managing cloud expenses.

Cloud Applications: Case studies of cloud computing in the field of Physics; Edge computing and its significance; Serverless computing; Artificial Intelligence and Machine Learning in the cloud; Future challenges and opportunities.

Texts/References:

1. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl, Zaigham Mahmood, and Ricardo Puttini; ISBN: 978-0133387520
2. "Cloud Computing Bible" by Barrie Sosinsky; ISBN: 978-0470903568
3. "Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS)" by Michael J. Kavis; ISBN: 978-1118617618
4. "Cloud Computing: Theory and Practice" by Dan C. Marinescu; ISBN: 978-0124046276
5. "Mastering Cloud Computing: Foundations and Applications Programming" by Rajkumar Buyya, Christian Vecchiola, and S. Thamarai Selvi; ISBN: 978-0124114548
6. "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things" by Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra; ISBN: 978-0128002049

PH419 - STATISTICS WITH 'R'
Credits-03 (2-0-1)

This course will be offered by the department of Applied Mathematics

Discipline Specific Elective (DSE) Courses/Minor: Credit: 04 (4-0-0)
(Choose any one course from a pool of DSE courses)

DSE-1

PHUD224-FUNDAMENTALS OF ELECTRO-OPTICS AND PHOTONICS
Credits: 03(3-0-0)

Course Objectives and Outcomes: *Brief description: An introductory course in photonics starting with the principles of EM wave, propagation, leading to component technologies (LEDs, lasers, modulators, photodetectors) and contemporary applications (sensors, signal/image processing, holography, communications, additive manufacturing). The goal is to prepare the student for advanced study in photonics or to succeed in a photonics workplace. The student will, in addition, have the background necessary to make assessments about electro-optical systems and techniques.*

Foundations of Optical Engineering: Introduction to Electromagnetic Field Theory: Maxwell's equations, Boundary conditions and their implications in optics; Energy Level Distributions and Semiconductor Physics: Band theory of solids and energy band diagrams, Carrier statistics and semiconductor behavior; Optical Materials, Band structure engineering and optical properties, Photonic crystals and metamaterials.

Wave Optics and Optical Systems: Reflection, Refraction, and Matrix Methods: optical systems, Lenses, Imaging; Aberrations: Lensmaker's equation and thin lens approximation, Optical imaging systems: magnification, resolution, Aberrations and their correction techniques.

Advanced Optical Phenomena and Techniques: Linear Systems and Transforms in Optics: Fourier optics and spatial frequency domain, Transfer functions and modulation transfer functions, Optical filtering and image processing techniques; Diffraction and Gaussian Beams: Gaussian beam propagation and beam quality parameters, Applications of diffraction in optics.

Optical Communication and Sensing: Guided Waves and Fiber Optics: Basics of waveguides and modes, Fiber optic principles and classifications, Fiber optic communication systems and components; Interferometry and Sensing Applications: Principles of interference and coherence, Interferometric sensors: fiber gyroscopes, pressure/temperature/flow sensors.

Advanced Optical Technologies and Applications: Light Sources, Detectors, and Modulators: Light-emitting diodes (LEDs) and semiconductor lasers, Photodetectors: photodiodes, photomultipliers; Optical modulators: electro-optic and acousto-optic devices; Holography and Optical Signal/Image Processing: Principles of holography and holographic imaging, Digital image processing techniques in optics, Applications in 3D imaging, security, and data storage; High-power laser applications: welding, cutting, additive manufacturing, Emerging trends and future directions in optical engineering

Texts/References:

1. Introduction to Electrodynamics, D. J. Griffith, Prentice Hall India (2009)
2. Introduction to Fourier Optics, Joseph W. Goodman, Roberts & Company Publishers; 3rd edition (22 April 2016)
3. An introduction to *fiber optics, A.K. Ghatak,* Cambridge University Press (1998)
4. Optical Engineering Fundamentals, Bruce H. Walker, McGraw-Hill Education (2010)
5. Field Guide to Optical Fiber Technology, Raman Kashyap, SPIE Press (2010)

PHUD224L-FUNDAMENTALS OF ELECTRO-OPTICS AND PHOTONICS
Credits: 01 (0-0-1)

Course Objectives and Outcomes: *This course is designed to provide students with a solid foundation in photonics through theoretical learning and hands-on laboratory experiences. Beginning with the principles of electromagnetic wave propagation, students will progress to studying essential component technologies such as LEDs, lasers, modulators, and photodetectors. The ultimate goal is to prepare students for advanced studies in photonics or to equip them with the necessary skills for successful employment in photonics-related industries. Additionally, students will develop the ability to assess and analyze electro-optical systems effectively.*

At least 06 experiments from the following:

1. To characterize the emission characteristics of Light-Emitting Diodes (LEDs) and understand their spectral properties.
2. To characterize the performance of photodetectors and understand their responsivity, noise characteristics, and bandwidth.
3. To understand Fourier optics principles and spatial frequency analysis using optical components.
4. To study Gaussian beam propagation characteristics and diffraction effects.
5. To investigate the principles and components of fiber optic communication systems.
6. To explore interferometry principles and their applications in sensing.
7. To explore the transmission properties of optical fibers and understand their attenuation and dispersion characteristics.
8. To demonstrate spatial filtering and its effect on the coherence and spatial characteristics of a laser beam. (To explore optical filtering techniques and their applications in image processing.)
9. To investigate high-power laser applications, such as welding, cutting, additive manufacturing, and explore emerging trends in optical engineering.
10. Recording and reconstruction of holograms.

Texts/References:
1. Optoelectronics & Photonics: Principles & Practices" by Safa O. Kasap
2. Introduction to Fourier Optics, Joseph W. Goodman, Roberts & Company Publishers; 3rd edition (22 April 2016)
3. An introduction to *fiber optics, A.K. Ghatak,* Cambridge University Press (1998)
4. **Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods**
5. Field Guide to Optical Fiber Technology, Raman Kashyap, SPIE Press (2010)
6. High-Power Laser Handbook" by Hagop Injeyan and Gregory Goodno

PH226-EXPERIMENTAL TECHNIQUES
Credits: 04(4-0-0)

Course objectives:
- *This course aims to describe the errors in measurement and statistical analysis of data required while performing an experiment.*

- *Also, students will learn the working principle, efficiency and applications of transducers and industrial instruments like digital multimeter, RTD, Thermistor, Thermocouples and Semiconductor type temperature sensors.*

Measurements: Accuracy and precision, Significant figures, Error and uncertainty analysis, Types of errors: Gross error, systematic error, random error, Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting, Gaussian distribution.
Signals and Systems: Fluctuations and Noise in measurement system, S/N ratio and Noise figure, Noise in frequency domain, Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise, Methods of safety grounding, Energy coupling, Grounding, Shielding: Electrostatic shielding, Electromagnetic Interference.

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems, Generalized performance of systems, Zero order first order, second order and higher order systems, Electrical, Thermal and Mechanical systems, Calibration, Qualitative difference between Transducers and Sensors, Types of sensors (Physical, Chemical and Biological), Characteristics of Transducers, Transducers as electrical element and their signal conditioning, Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning, Linear Position transducer: Strain gauge, Piezoelectric, Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers, Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.
Digital Multimeter: Comparison of analog and digital instruments, Block diagram of digital multimeter, principle of measurement of I, V, C, Accuracy and resolution of measurement.
Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge, Q-meter and its working operation, Digital LCR bridge.
Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path, Application of vacuum, Vacuum system- Chamber with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump and Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode).

Texts/References:

1. Experimental Methods for Engineers, J P Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A K Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
3. Transducers and Instrumentation, D V S Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C S Rangan, G R Sarma, V.S.V. Mani, Tata McGraw Hill
5. Electronic circuits: Handbook of design & applications, U Tietze, Ch Schenk, Springer

DSE-2

PH319 - CLASSICAL DYNAMICS AND RELATIVITY
Credits: 04(4-0-0)

Course objectives and outcomes: *This course begins with the review of Newton's Laws of Motion and ends with the Special Theory of Relativity by 4-vectoer approach and fluids. Students will also appreciate the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach). By the end of this course, students should be able to solve the seen or unseen problems/numerical in classical mechanics.*

Classical Mechanics of Point Particles: Review of Newtonian Mechanics, Degrees of freedom, generalized coordinates and velocities. Lagrangian, action principle, external action, Euler-Lagrange equations. Constraints. Applications of the Lagrangian formalism. Generalized momenta, Hamiltonian, Hamilton's equations of motion. Legendre transform, relation to Lagrangian formalism. Phase space, Phase trajectories. Applications to systems

with one- and two-degree, small oscillations.
Rigid Body Dynamics: Kinematics, Euler angles, Infinitesimal rotation, Motion of heavy symmetrical top with one point fixed, other applications.
Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction, simultaneity Four-vectors: space-like, time-like and light-like. Four-displacement [Xμ = (ct, r)], 4-velocity [Uμ = γ (c, u)], 4-acceleration (Aμ). Metric tensor (gμν or gμν) and alternating tensor (abcd abcd ∈ or ∈) and their properties. Four-momentum [Pμ = (E/c, p)] and energy-momentum relation. Concept of four-force (Fμ). Transformation Laws of Four-force. Norms: XμXμ, U μUμ, A μAμ, Fμ Fμ. Orthogonal relations: UμAμ = 0, Pμ Fμ = 0. Conservation of four-momentum. Lagrangian and Hamiltonian of a relativistic free particle.

Texts/References:

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
4. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
5. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
6. Classical Mechanics, Tai L. Chow, CRC Press.
7. David Tong: Lectures on Theoretical Physics, University of Cambridge.

PH321-ATMOSPHERIC PHYSICS
Credits-04 (4-0-0)

Course objectives: *This paper aims to describe the characteristics of earth's atmosphere and also its dynamics. Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.*

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.
Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.
Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.
Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

Texts/References:

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd Edition. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

DSE-3

PH323 – NUMERICAL ANALYSIS

Credits-04 (4-0-0)

The aim of the course is to analyze the basic techniques for the efficient numerical solution of problems in science and engineering. As the outcome of the course, the students will be skilled in error analysis, iterative methods, root finding, interpolation, and approximation of functions, integration and differential equations.

Errors and iterative Methods: Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods.
Solutions of Algebraic and Transcendental Equations: Fixed point iteration method, Bisection method, Secant Method, Newton Raphson method, Generalized Newton‟s method. Comparison and error estimation.
Interpolation: Forward and Backward Differences. Symbolic Relation, Differences of a polynomial, Newton‟s Forward and Backward Interpolation Formulas.
Least Square fitting: Fitting a straight line, Non-linear curve fitting: (a) Power function, (b) Polynomial of nth degree, and (c) Exponential Function, Linear Weighed Least square Approximation.
Numerical Differentiation: Newton‟s interpolation Formulas & Cubic Spline Method, Errors in Numeric Differentiation, Maximum and Minimum values of a Tabulated Function.
Numerical Integration: Generalized Quadrature Formula, Trapezoidal Rule, Simpson‟s 1/3 and 3/8 Rules, Gauss-Legendre Formula.
Solution of Ordinary Differential Equations: First Order ODE‟s: solution of Initial Value problems using Euler‟s Method and Modified Euler's method.

Texts/References:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. The Art of Scientific Computing, W.H. Press et. al., 2nd Edn., 2013, Cambridge University Press.
3. Numerical Analysis: Mathematics of Scientific Computing, David Kincaid, Ward Cheney, 1991, Cole Publishing Company.
4. A first course in Numerical Methods, U. M. Ascher & C. Greif, 2012, PHI Learning

PH325-RENEWABLE ENERGY AND ENERGY HARVESTING

Credits-04 (4-0-0)

Course objectives: *The aim of this course is to impart theoretical knowledge to the students and to provide them with exposure and hands-on learning wherever possible.*

Fossil Fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources, An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning, Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices, Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.
Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power
Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications. Carbon captured technologies, cell, batteries, power consumption.
Texts/References:

1. Non-conventional energy sources, B H Khan, McGraw Hill
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rdEdn., 2012, Oxford University Press
4. Solar Energy: Resource Assessment, Handbook, P Jayakumar, 2009
5. Photovoltaics, J Balfour, M Shaw and S Jarosek, , Lawrence J Goodrich (USA)

DSE-4

PH327 – OPTICAL COMMUNICATIONS
Credits-04 (4-0-0)

Course objectives: *This course aims to make the students learn the fundamentals of optical communication systems, including fiber optics, optical transmitters and receivers, modulation techniques (ASK, FSK, PSK, QAM, OFDM), optical amplifiers, and multi-channel systems (WDM, TDM, CDM). Students will gain a comprehensive understanding of the design and performance of modern optical networks.*

Basic concepts of communication system: Analog & digital signal formats, Spectral bands, Transmission Channels; Optical communication systems overview;
Optical Fibers: Geometrical Optics description, Wave propagation, Optical fiber modes, Fiber losses, Dispersion, Pulse propagation, Nonlinear effect (Conceptual only);
Optical Transmitters: Light emitting diodes, Semiconductor Lasers, Transmitter design;
Optical Receivers: P-I-N and Avalanche photodiode; Receiver design; Receiver noise and sensitivity; Receiver performance;
Optical Modulation: Digital modulation formats: ASK, FSK, PSK, QAM, Bit-error-rates, System performance, Optical implementation; Higher-order modulation (star and square QAM) and Multicarrier modulation (OFDM), Optimum receiver principles
Optical Amplifiers: Semiconductor optical amplifier, Raman Amplifier, Erbium-Doped Fiber Amplifier;
Multi-channel systems : WDM Lightwave Systems, WDM Components, Time-Division Multiplexing, Subcarrier Multiplexing, Orthogonal Frequency Division Multiplexing (OFDM), Code-Division Multiplexing.

Texts/References:

1. G. Agrawal, “Fiber Optics Communication Systems,” Wiley.

2. G. Keiser, **“Optical Communications Essentials”,** Mc-Graw-Hill (2003)
3. J. M. Senior, **“Optical Fiber communications”,** Ed.3, Prentice-Hall (2009)
4. A. W. Snyder and J. Love, **“Optical Waveguide Theory”**, Springer (**2010**).
5. A. Ghatak and K. Thyagrajan, **“Introduction to Fiber Optics”,** Cambridge University Press

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PH329 – RADIATION PHYSICS

Credits: 3(4-0-0)

Course objectives: *It is a course focus on the applications of nuclear techniques and radiation protection. It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure. This will prepare the work force for jobs in industry and medical fields. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics.*

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions
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.
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 Dosimetry.
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.
Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.
Radiation And Radiation Protection: Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose.

Texts/References:

1. Nuclear and Particle Physics by W. E. Burcham and M. Jobes, Harlow Longman Group, 1995.
2. G. F. Knoll, Radiation detection and measurement, 4th Edition, Wiley Publications, 2010.
3. Thermoluminescence dosimetry by A. F. Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5).
4. Fundamental Physics of Radiology by W .J. Meredith and J.B. Massey, John Wright and Sons,UK, 1989.
5. An Introduction to Radiation Protection by A. Martin and S. A. Harbisor, John Willey & Sons,Inc. New York, 1981.
6. Medical Radiation Physics by W. R. Hendee, Year book Medical Publishers, Inc., London,1981.
7. Nuclear Physics: Principles and Applications by John Lilley, Wiley Publication, 2006.
8. Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

9. Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.
10. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3.
11. No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9(2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).
12. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources irradiation facilities, 2011.
13. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources, 2007.

DSE-5

PH320-ADVANCED QUANTUM MECHANICS
Credits: 04 (4-0-0)

Course objectives : *The topics inclues various approximate methods (time-independent perturbation theory and time-dependent perturbation theory to solve simple problems, the variational method, WKB approximation), symmetries exists in various quantum particles including spins and identical particles and the fundamentals of relativistic quantum mechanics.*
Course outcomes : *The students will be able to solve real world problems and gain knowledge about fundamental quantum mechanical processes in nature.*

Angular Momentum and Matrix representation : Dirac's bra and ket algebra, angular momentum and their properties, spherical harmonics, addition of angular momenta and Clebsch-Gordan coefficients(j=1/2 & 1)- and spin Pauli's spin matrices,
Time-independent perturbation theory: Harmonic oscillator, Zeeman Effect, Stark effect (Non-degenerate cases)
Variational method: Principles and application to particle in a box, simple harmonic oscillator, hydrogen atom.
WKB approximation: Principles and condition for validity, Bohr's quantization condition, applications to tunneling such as alpha particle, field emission.
Time-dependent perturbation theory: Schrodinger and Heisenberg picture, first order and harmonic perturbations, transition probability, Fermi's golden rule, adiabatic and sudden approximations.
Fundamental Theory of Scattering: Born approximation and its applications to square well potential and Yukawa potential, partial wave analysis, phase shifts, optical theorem, scattering by square well potential and rigid sphere.
Elements of relativistic quantum mechanics: Klein-Gordon equation and Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, physical interpretation, non-relativistic limit of Dirac equation, Coherent state, squeezed state, number state, quantum entanglement, quantum cryptography, quantum computation.

Texts/References:
1. Quatum Mechanics: Concepts and Applications, N. Zettilli, Wiley, Second Edition (2009)
2. Quantum Mechanics L. I. Schiff, Tata McGraw-Hill, Third Edition (2010)
3. Quantum Mechanics, F. Schwabl, (4th edn, Springer, 2007).
4. Quantum Mechanics, B. H. Bransden and C. J. Joachain (2nd edition Pearson, 2000)
5. Principles of Quantum Mechanics, R. Shankar, (2nd edn, Springer, 1994).
6. Quantum Mechanics: Fundamentals and applications to technology Jasprit Singh, Wiley-VCH Verlag (2004)
7. Quantum Physics, S. Gasiorowicz (3rd edn, Wiley, 2003)

8. Quantum Mechanics: Non-Relativistic Theory, Volume 3, L. D. Landau and L. M. Lifshitz (Butterworth-Heinemann, 3rd edn, 1981).

PH322 – SPECTROSCOPIC TECHNIQUES
Credits-04 (4-0-0)

Objectives and outcomes: *This course introduces the fundamental principles and practical applications of spectroscopy, focusing on the interaction of light with matter. Topics include basic electromagnetic spectrum concepts, instrumentation essentials such as light sources and detectors, and various spectroscopic techniques like UV-Visible-NIR, Raman, and NMR spectroscopy. Students explore advanced topics including non-linear spectroscopy, photochemistry, and state-of-the-art time-resolved spectroscopic methods, gaining a comprehensive understanding of how spectroscopy informs scientific research and industrial applications.*

Light-matter interactions: Introduction to spectroscopy; basic concepts, terminology and features including EM spectrum, transitions, energy levels, line widths, etc.
Introduction to Spectroscopy Instrument: Different light sources, filters, mirrors, lenses, grating, prism, slits, detectors and laser safety glasses.
Laser operation and sources, Electronic spectroscopy (UV-Visible-NIR) and examples. Absorption and fluorescence spectroscopy, including uses in various fields.
Vibrational spectroscopy and introduction to IR and Raman. Advanced Raman techniques: Surface enhancement, plasmonic and some bioanalytical applications. Nuclear magnetic resonance (NMR) spectroscopy of nuclear spin states.
Non-linear spectroscopy applicable to the study of molecules, surfaces and interfaces. Photochemistry –What can we learn about chemical reactivity from spectroscopic measurements?
Conventional spectroscopy approaches: Kinetic energy release spectroscopy. Time-resolved spectroscopy – Wave packets and transition state spectroscopy. The current state of the art – From femtoseconds to attoseconds. Analysis of experimental measurements.

Texts/References:
1. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch
2. Spectroscopy: Principles and Instrumentation by Peter F. Bernath
3. Infrared and Raman Spectroscopy: Principles and Spectral Interpretation by Peter Larkin
4. Principles of Fluorescence Spectroscopy by Joseph R. Lakowicz
5. NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry by Harald Günther
6. Mass Spectrometry: Principles and Applications by Edmond de Hoffmann and Vincent Stroobant
7. Introduction to Infrared and Raman Spectroscopy" by Norman B. Colthup, Lawrence H. Daly, and Stephen E. Wiberley.

DSE-6

PH324-NANOSCIENCE AND NANOTECHNOLOGY
Credits: 04(4-0-0)

Course objectives: *The main goal of this subject is to provide fundamental concepts of nanoscience and basic understanding of various fabrication and characterization techniques of nanostructured materials.*
Course outcomes: *The students gain enriched knowledge on the properties of materials at the nanoscale and can synthesize and implement these materials for various technological applications.*

Nanoscale Physics: Introduction to different nanosystems and their realization, Quantum size-effects, Characteristic scale for quantum phenomena, Quantum wells, Quantum wires, and Quantum dots, Nano-clusters and Nanocrystals, Band structure and Density of states for low-dimensional structures, Quantum confinement of carriers in 0D, 1D, 2D nanostructures and its consequences. Coulomb blockade, Magic numbers, Optical properties of Nanosystems, Photoluminescence and Absorption spectra, Semiconductor nanocrystals, Blue-shift, Excitons and Plasmons, Localized Surface Plasmons, **Nanofabrication Techniques:** Top-down and Bottom-up approaches, **Chemical Techniques:** Co-precipitation, Sol-Gel, Hydrothermal, Spin coating and Dip coating, Ball milling, Nucleation and growth of nanostructures and nanodimentional thin films, **Physical Techniques:** Physical vapor deposition (PVD), Chemical vapor deposition (CVD), dc, rf, reactive and magnetron sputtering, pulsed laser deposition (PLD), molecular beam epitaxy (MBE), Photolithography, **Technologically important nanostructures:** Buckminster fullerene (C_{60}), Carbon nanotubes (CNT), Graphene and Magnetic Nanostructures, Applications of nanomaterials in Biology, Environment, and Energy.

Texts/References:

1. C. P. Poole, **"Introduction to Nanotechnology"**, Wiley-IEEE (2003).
2. T. Pradeep, **"Nano: The Essentials"**, McGraw-Hill (2007).
3. H.S. Nalva (editor), "**Handbook of Nanostructured Materials and Nanotechnology"**, Academic Press (1999).
4. S. K. Kulkarni, **"Nano Technology Principles and Practices"**, Capital Publishing Company (2006).
5. Silvana Fiorito, **"Carbon Nanotubes"**, Pan Stanford Publishing (2007).
6. Richard Booker and Earl Boysen, **"Nanotechlongy"**, Wiley (2005).
7. M. Ohring, **"Materials Science of Thin Films"**, Academic Press (2012).

PH326 – BIOPHYSICS AND APPLICATIONS

Credits-04 (4-0-0)

Course objectives: *At the end of the course, the student should be able to*

- *Understand the physical principles behind the various techniques available for interrogating biological macromolecules.*
- *Know how to correctly interpret the results obtained from such studies.*
- *Choose and apply most relevant biophysical technique for characterizing the dynamic behavior of a macromolecule, especially proteins.*

Course outcomes: *On Completion of this course, students can*

- *Analyse and interpret data from various spectroscopic techniques*
- *Understand the important aspects of the macromolecular structures*
- *Understand how various methods such as hydrodynamic, chromatographic methods etc. Can be used for differentiating biological macromolecules*
- *Comprehend the utility of different types of microscopy and gain knowledge of new concept in the solution of practical oriented problems*

Unit-1: Introduction to Biophysics
Definition, scope, and interdisciplinary nature of biophysics, Historical development and milestones, Classification: Molecular Biophysics, Cellular Biophysics, Biomechanics, Computational Biophysics
Unit-2: Spectroscopic techniques used for analysis
a) UV & Visible absorption spectrophotometry: Lambert Beer's Law, molar extinction coefficient and its determination, instrumentation & applications
b) Fluorescence Spectroscopy: principles and applications, Polarization of light, Fluorescence studies of plane-polarized light.
c) Other common spectroscopic techniques: Principles, use and interpretation of Optical Rotatory Dispersion (ORD), Circular Dichroism (CD).
Unit-3: Macromolecular Structure Determination
a) Introduction to X-ray Crystallography: basis of crystallography theory, symmetry, instrumentation and

biological applications, macromolecular diffraction, and methods of phase determination.
b) Principles of magnetic resonance spectroscopy: Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) and biological applications, Relaxation studies.
Unit-4: Emerging Biophysical methods:
Hydrodynamic Methods: Viscosity, Sedimentation equilibrium and Velocity Centrifugation, Density Gradient method, applications to bio-macromolecules and bio-materials.
Chromatography: Partition and Adsorption Chromatography, paper and thin layer chromatography, gel filtration, ion-exchange and affinity chromatography. GLC, HPLC and FPLC, Emerging trends in chromatography.
Radioactive methods: Radioactive isotopes, nature of radioactive decay, sample preparation and counting, G.M. and Scintillation counters, Precautions in radio isotope handling, Autoradiography and its biological applications.
Unit-5: Radiation Biophysics:
(a) X-Ray: Effects on Bio-macromolecules.
(b) Gamma Radiation: Molecular Effects of Gamma Radiation, Radiation Chemistry of Water, Free Radicals, Effects on Biomolecules & Molecular Structures: Radiation Effects on Proteins, Radiation Effects on Nucleic Acids, Radiation Effects on Membranes. Effects on Cells and Organalles
(c) Ultraviolet Radiation: Effects on Bio-macromolecules & Molecular Structures, UV Radiation Effects on Proteins, Nucleic Acids, Cells and Organelles.
(d) Alpha & Beta Radiations: Effects on Cells and Organalles, human body.
(e) Radiation Hazards & Protection: Radiation Effects and Genetics, Methods to combat ionizing, non-ionizing and particle radiations, use of radiations in cancer & other diseases.
Unit-6: Microscopic Biophysical Techniques
Optical Microscope, Fluorescent Microscope, Confocal Microscope, Electron Microscope, Applications of each microscopic method.
Unit-7: Applications of Biophysics
Drug design and delivery, Biophysical basis of medical imaging techniques, Biophysics in understanding diseases and therapies.

Texts/References:

1. "Biophysics: An Introduction" by Rodney Cotterill (Wiley) 2002.
2. Principles of Fluorescence Spectroscopy by Lakowicz, Joseph R. (Springer) 2006.
3. Molecular Fluorescence: Principles and Applications by Bernard Valeur, Mario Nuno Berberan-Santos (Wiley) 2012.
4. Handbook of Fluorescence Spectroscopy and Imaging: From Single Molecules to Ensembles by Markus Sauer, Johan Hofkens, Jörg Enderlein (Wiley) 2010
5. NMR – Conformation of Biological Molecules by Govil G. &Hosur R. V. (Springer- Verlag) 2012.
6. Modern Optical Spectroscopy: With Exercises and Examples from Biophysics and Biochemistry by William W. Parson (Springer) 2016.

DSE-7

PH416 – PHOTOLITHOGRAPHY AND DEVICE FABRICATION TECHNIQUES
Credits-04 (4-0-0)

Course objectives: *This course will provide a detailed overview of cleanroom-based processes for device fabrication. A cleanroom is a controlled environment in which micro and nano devices are manufactured. The course includes all the steps of device fabrication including photolithography process. The students will learn fabrication of multilayer devices like light emitting diodes, solar cells, sensors etc. The required device characteristics for commercialization will also be discussed in this course.*

Fundamentals of Photolithography, Few commercial Photolithography systems and their components: mask aligner, Steppers, writing tool, inspection tool, wafer track etc. Photo resists (PR), Positive and negative photo

resists, Photo Resist Parameters, Developers, Importance of transparent conducting oxides films for devices, Optical and electronic properties (absorption, resistivity, work function etc.) of indium tin oxide (ITO) and Fluorine doped tin oxide (FTO) thin film. (15 Lectures)
ITO and FTO patterning. Key steps for doped Silicon photolithography, growth of oxide layer, surface preparation and coating of the Photo resist, Photo mask fabrication, Chromium etching, Optical exposure. (15 Lectures)
Introduction to working mechanism of Solar Cells and Light emitting diodes, Fabrication steps of devices (Inorganic, Organic, DSSC, Perovskite solar cells). Patterning. Surface treatment, evaporation or coating process and encapsulation, (20 Lectures)
Major challenges in device fabrication, optical out-coupling and approaches, Commercialization issues for solar cell and display devices. (10 Lectures)

Texts/References/Resources
1. S.M.Sze, VLSI Technology, Tata McGraw Hill Edition (2003).
2. Franky So,'Organic Electronics', CRC Press (2010).
3. Web: http://www.nptel.ac.in

PH418 – CHARACTERIZATION TECHNIQUES
Credits-04 (4-0-0)

Course objectives: *The course familiarizes students with various type of functional materials, their properties, and applications in various devices. It offers a detailed understanding of various research instruments, their working principles and instrument user instructions. The course also expertise students for analysis of data acquired from various material characterization instruments.*
Course outcomes: *The students acquire experience working in industrial or research lab settings as a part of a team, through the learning of various characterization technique theoretically in this course.*

Crystallography, X-Ray Diffraction Techniques, Small angle X-Ray scattering, Electron diffraction, Neutron Diffraction, X-Ray Fluorescence (XRF) spectroscopy, Scanning probe microscopy (AFM and STM), Electron optics, Electron Microscopy-Transmission and Scanning Electron Microscopy (TEM, SEM), X-ray photoelectron spectroscopy (XPS), Electrical characterization: Vander Pauw method, Capacitance measurements, Hall measurements at low and high temperatures, Giant magnetoresistance (GMR), Electrical conductivity and trapping parameter measurement in semiconductors and insulators, Optical characterization: UV-Visible spectroscopy, Spectroscopic ellipsometry (for determination of optical constants), photoluminescence (PL), compositional analysis employing Auger Electron spectroscopy (AES), Magnetic characterization: Superconducting Quantum Interference Device (SQUID), Thermal analysis (DTA/TGA).

Texts/References:
1. R. P. Prasankumar (Editor), A. J. Taylor (Editor), **"Optical Techniques for Solid-State Materials Characterization"**, CRC Press (**2011**).
2. B. D. Cullity, S.R. Stock, "Elements of X-Ray Diffraction", Prentice Hall (2001).
3. J. F. Watts, J. Wolstenholme, **"An Introduction to Surface Analysis by XPS and AES",** Wiley **(2003**).
4. P. J Goodhew, J. Humphreys, R. Beanland, **"Electron Microscopy and Analysis",** Taylor & Francis (**2000).**

DSE-8

PH420 – QUANTUM TECHNOLOGIES
Credits-04 (4-0-0)

Course Description: *This course introduces quantum technologies, covering quantum mechanics fundamentals,* *quantum computing algorithms and hardware, quantum cryptography, quantum sensing and metrology, and quantum simulation for materials science. Students will gain an understanding of key quantum concepts and their applications in emerging technologies.*

Course Objectives:

- To understand the fundamental postulates of quantum mechanics and the concept of qubits.
- To learn quantum computing principles, algorithms, error correction, and hardware platforms.
- Grasp the principles and applications of quantum sensing and metrology.

Module 1: Introduction to Quantum Mechanics
Overview of classical physics: Limitations, paradoxes (electron diffraction, quantum entanglement); Postulates of quantum mechanics: Superposition, entanglement, measurement; Quantum bits (qubits): Representation, operations; Quantum states: Pure and mixed states, density matrix.
Module 2: Quantum Computing
Quantum circuits: Gates, universality; Quantum algorithms: Grover's search, Shor's factoring algorithm; Quantum error correction: Quantum codes, fault-tolerant computing; Quantum hardware platforms: Superconducting qubits, trapped ions, photonic qubits.
Module 3: Quantum Cryptography
Principles of classical cryptography: Symmetric and asymmetric key cryptography; Quantum key distribution (QKD): BB84 protocol, security proofs; Quantum secure direct communication (QSDC): Protocols and applications; Post-quantum cryptography: Introduction to resistant algorithms.
Module 4: Quantum Sensing and Metrology
Quantum sensors: Atomic clocks, magnetometers, accelerometers; Quantum metrology: Precision measurements, quantum limits; Quantum imaging: Super-resolution microscopy, ghost imaging; Applications in various fields: Biology, medicine, materials science.
Module 5: Quantum Simulation and Materials Science
Quantum simulation: Basic principles, quantum advantage; Quantum chemistry: Molecular simulations, drug discovery; Quantum materials: Phase transitions, superconductivity; Quantum machine learning: Introduction to quantum algorithms for machine learning.

Texts/References:

1. "Quantum Computing: Explained" by David McMahon
2. "Quantum Mechanics: The Theoretical Minimum" by Leonard Susskind and Art "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang
3. "Quantum Computing: A Gentle Introduction" by Eleanor Rieffel and Wolfgang Polak
4. "Quantum Cryptography: Theory and Practice" by Nicolas Gisin and Grégoire Ribordy
5. "Quantum Computing and Security: An Introduction" by Markus Grassl, Boulat A. Klyachko, and Alexander S. Shirokov
6. "Quantum Metrology" by Vittorio Giovannetti, Seth Lloyd, and Lorenzo Maccone
7. "Quantum Sensing and Metrology" by Christopher Gerry and Peter Knight
8. "Quantum Simulation" by Ian McCulloch

PH422 – ASTRONOMY AND ASTROPHYSICS

Credits-04 (4-0-0)

Course objectives and course outcomes: *The syllabus of "Astronomy and Astrophysics" has been designed in a manner that provides excellent platform for understanding the origin and evolution of the Universe. It gives a comprehensive introduction on the measurement of basic astronomical parameters such as astronomical scales, luminosity and astronomical quantities. This course gives an overview on key developments in observational astrophysics. This primarily includes the telescope optics, instrument detectors and the choice of observation sites. The syllabus also reviews the formation of planetary system and its evolution with time. This course nicely covers the physical properties of Sun and the components of the solar system; and stellar and interstellar* *components of our Milky Way galaxy. It emphasizes on the physical laws that enable us to understand the origin and evolution of galaxies, presence of dark matter and large-scale structures of the Universe.*

Astronomical Observations : Our current understanding of the Universe (broad idea of cosmology, galaxy clusters, galaxies, stars, and planets), Astronomical coordinates, Flux, Luminosity, Magnitude, Astronomical distance scale (AU, light year, parsec, megaparsec) and mass scale, Refracting and reflecting telescopes, Concept of angular size and its relation to physical size, Diffraction limit, Astronomical seeing, Need for Space Telescopes, Basic observational techniques in optical, radio and high-energy (Xray/ Gamma-ray) astronomy, outlines of spectroscopic and polarimetric observations, Stellar parameters (mass, radius, temperature) from binary systems, Extrasolar planets, Continuous, emission, and absorption spectra, Formation of spectral lines, HR diagram, Main sequence.
Stellar Astrophysics: Virial theorem, Hydrostatic equilibrium, Concept of Opacity, Stellar energy sources, Solar neutrino, Jeans Criterion, Interstellar medium, Formation of protostars, evolution of stars before, during and after their location on the main sequence, HII region, Stromgren Sphere, Supernovae, Stellar Pulsation, Degeneracy pressure, White dwarfs, Chandrasekhar limit, Neutron stars, Pulsars, Black holes, Close binary systems, accretion disks.
Galactic Astrophysics: Spiral, elliptical and irregular galaxies (rotation, spiral structure, dark matter), Interaction and evolution of galaxies (evolutionary relation of spirals and ellipticals), Supermassive black hole (MBH vs. Mbulge, Black hole-galaxy coevolution), Morphology, Kinematics, Galactic center.
Extragalactic Astrophysics: Galaxy clusters, Cosmic distance ladder (Parallax, Cepheid variables, Hubble's law, Type IA supernovae), Observations of active galaxies all over the electromagnetic spectrum, Unification model, Importance in galaxy formation and evolution, Gamma-ray bursts.

Texts/References:

1. An Introduction to Modern Astrophysics and Cosmology (Second Edition), B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co., 2006
2. Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory
3. Saunders College Publishing, 1998 Fundamental of Astronomy (Fifth Edition), H. Karttunen et al. Springer, 2007
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Publication, 2001
5. The Cosmic Perspective (Eighth Edition), J. O. Bennet, M. Donahue, N. Schneider & M. Voit, Pearson Publications, 2017
6. The Physical Universe: An Introduction to Astronomy, Frank Shu, Oxford University Press, 1985
7. Astrophysics: Stars and Galaxies, K. D. Abhyankar, Universities Press, 2001.

PH424 – THIN FILM TECHNOLOGY AND VACUUM SCIENCE

Course objectives: *The course familiarizes students with various type vacuum systems and their parts such as pumps, gauges, and other important parts. Other objective of the course is to teach students about the working principle and instrumentation of various thin film synthesis techniques. Students also learn about the properties of thin films for different applications.*
Course outcomes: *The students acquire detailed knowledge and experience for working in industrial or research lab where vacuum based thin film deposition techniques are used for device fabrication.*

Pressure and Vacuum: Behavior of gases, gas transport phenomenon, viscous, molecular and transition flow regimes, measurement of pressure, pressure gauges, residual gas analyses, Vacuum: Need in research and industry, gas throughput, production of vacuum, mechanical pumps, rotary pump, diffusion pump, Getter and ion pumps, cryopumps, turbo-molecular pump, principles of low, high, and ultra-high vacuum, production and measurement systems, materials for vacuum systems, design aspects of vacuum systems for different applications, leak detection, Thin Film Deposition: Thin film nucleation and growth, atomistic and kinetic models of nucleation, physical vapor deposition (PVD), chemical vapor deposition (CVD), plasmas, discharges and arcs, dc, rf, reactive and magnetron sputtering, pulsed laser deposition (PLD), epitaxy, molecular beam epitaxy (MBE), Chemical Techiques: Sol-Gel, spray pyrolysis, mechanical, Characterization of thin film and surfaces: structural, chemical, electrical, optical characterization, mechanical properties of thin films, metallic, semiconducting, insulating thin films, multilayered thin films, applications of thin films.

Texts/References:

1. M. Ohring, **"Materials Science of Thin Films"**, Academic Press (**2012**).
2. K. L. Chopra, **"Thin Film Phenomena"**, Mc Graw-Hill (**1969**).
3. Eishabini-Riad, F. D. Barlow, **"Thin Film Technology Handbook"**, McGraw-Hill (**1998**).
4. D. M. Hoffman, B. Singh, J. H. Thomas, **"Handbook of Vacuum Science & Technology",** Academic Press (**1998**).
5. J. M. Lafferty (Ed.), **"Foundations of Vacuum Science & Technology",** Wiley (**1998**).

VALUE ADDITION COURSES (VAC) OFFERED BY THE DEPARTMENT OF APPLIED PHYSICS, Credit-02 (2-0-0)

PHVAC01 – PHYSICS OF HOUSEHOLD APPLIANCES
Credits-02 (2-0-0)

Course objectives:

- *This course comprises the study of principle of various household appliances, electricity and electric wiring. It also provides the knowledge of entertainment gadgets such as radio, television and how the internet and mobile phones work.*
- *Students would be able to better handle and manage the household devices*.

Electricity: Generation and transmission of electricity, Safety features in household electric wiring: Fuse, MCB, Earthing, Electric meter, Battery charger, Invertor, UPS, Voltage stabilizer
Light Sources: Different light sources, Incandescent lamp (Electric bulb), Fluorescent tube, CFL, LED
Motorized equipment: Washing machine for cleaning clothes, Dish washer, Food processor (Mixer/blender, grinder, juicer, chopper etc.), Electric chimney, Vacuum cleaner
Heating appliances: Electric iron, Electric water heater (Rod, Geyser), Temperature control in household gadgets: various types of thermostats, Solar Energy and its applications (Solar geyser, solar cooker etc.)
Cooling Appliances: Refrigeration and air conditioning, Air conditioners and air coolers, Basic knowledge of ducting
Entertainment Gadgets: Camera; Elementary knowledge of Radio- AM and FM; Television: transmission and reception, concept of colour television, Advances in TV technology
Remote control and Communication: Free space communication, Optical fiber communication (eg: internet), Remote control (TV, AC, Fan), Telephone (Land line), Mobile phones
Consumer Awareness: Guarantee and warranty of equipment, Precautions while using equipment and servicing of equipment

Texts/References:

1. Household Physics (2012), Claude H. Brechner, Hardpress.
2. Elements of Electrical Gadgets, K. B. Bhatia, Arya Book Depot, 1993.
3. Troubleshooting and Repairing Major Appliances, Eric Kleinert, ISBN-13:978-0071770187, ISBN-10:0071770186.

PHVAC02 – PHYSICS OF PLANETS
Credits-02 (2-0-0)

Solar System Overview: The Sun, Planets, Moons, Asteroids, Comets, Dwarf planets, Location. Classification of planets: Terrestrial, Jovian, and exoplanets, Basics of planetary system formation

Orbital Dynamics: Principal, Application, Type of Orbits, Orbital elements, Kepler's laws, Gravitational forces and orbital stability, Tidal forces and resonances,
Planetary Interiors: Internal structure of terrestrial and giant planets, Heat sources and thermal evolution, Basics of planetary magnetism,
Planetary Atmospheres: Atmospheric composition and structure, Greenhouse effect and climate stability, Atmospheric escape mechanisms,
Surface and Geological Processes: Impact cratering and volcanism, Surface erosion and tectonics, Evolution of planetary surfaces,
Exoplanets and Habitability: Methods for detecting exoplanets, Basic criteria for habitability, Future missions and the search for life.

References:

1. **"Planetary Sciences"** by Imke de Pater and Jack J. Lissauer
2. **The New Solar System"** by J.K. Beatty, C.C. Peterson, and A. Chaikin
3. **Physics and Chemistry of the Solar System"** by John S. Lewis
4. **An Introduction to the Solar System"** by David A. Rothery, Neil McBride, and Iain Gilmour
5. Research papers and resources from journals like *Icarus* and *Planetary and Space Science*.
6. Supplementary material from *NASA Planetary Science Resources*

PHVAC03 – PHYSICS OF EARTH

Credits-02 (2-0-0)

The Earth: Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.
The Hydrosphere: The oceans, their extent, depth, volume, chemical composition, River systems. **The Atmosphere**: Layers, variation of temperature with altitude, variation of density and pressure with altitude, cloud formation, Tides. Tsunamis.
Dynamical Processes: The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth’s core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations: Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution.
The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth’s heat budget. Cyclones and anti-cyclones. Earth’s temperature and greenhouse effect. Recent climate changes, The Indian monsoon system.
Evolution: Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes). **Disturbing the Earth:** Human population growth, Atmosphere: Greenhouse gas emissions, climate change, air pollution. Hydrosphere: Fresh water depletion. Geosphere: Chemical effluents, nuclear waste. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Reference Books:

1. Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
2. Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
3. The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
4. Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
5. Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
6. The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.

7. The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
8. Climate Change: A Very Short Introduction, Mark Maslin, 3rd Edition, 2014, Oxford University Press.

Inter-disciplinary courses (IDC) Credit: 03 (3-0-0) / GE courses (GE) Credit: 04 (3-0-1 or 4-0-0) for other Departments/Disciplines

PH123-MECHANICS
Credits-03 (3-0-0)

Course objectives:

- *The objective of this course is to enhance the understanding of the basics of mechanics.*
- *This course comprises the study of basic concepts and formulations of Newton's Laws of motion, rotational dynamics, Gravitation, and Oscillations and Special theory of Relativity.*
- *Students will understand the application of concepts by solving the problems/numerical in mechanics.*

Vectors: Vector algebra, Scalar and vector products, Gradient, divergence and curl of scalar/vector fields.
Laws of Motion: Frames of reference, Inertial and Non-inertial frames, Galilean Transformations, Newton's Laws of motion, Dynamics of a system of particles, Centre of Mass, Center of mass for discrete and continuous systems having cylindrical and spherical symmetry.
Work and Energy: Work-Energy theorem for conservative forces, Force as a gradient of Potential Energy, Conservation of momentum and energy, Elastic and inelastic Collisions, Motion of rocket.
Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia, Theorem of parallel and perpendicular axes (statements only), Calculation of Moment of Inertia of discrete and continuous objects, Kinetic energy of rotation.
Gravitation: Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws, Satellite in circular orbit and applications, Geosynchronous orbits.
Oscillations: Simple harmonic motion, Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages, Compound pendulum, Differential equations of damped oscillations.
Special Theory of Relativity: Postulates of Special Theory of Relativity, Lorentz transformations, Length contraction, Time dilation, Twin Paradox, Relativistic variation of mass, Mass-energy equivalence, Transformation of Energy and Momentum, Massless particles.

Texts/References:

1. An Introduction to Mechanics, Daniel Kleppner and Robert Kolenkow, Cambridge University Press, 2014.
2. Mechanics, D.S. Mathur, S. Chand & Co., 2016
3. Mechanics, J.C. Upadhyaya, Ram Prasad Publication, 2017
4. University Physics, F W Sears, M W Zemansky and H D Young13th Ed., 1986, Addison-Wesley
5. Mechanics: Berkeley Physics course, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill

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PH 123L - MECHANICS LAB
Credits: 01 (0-0-2)

Course objectives: *This laboratory provides the practical knowledge about laws of motion, moment of inertia and gravitation etc. Students would also get familiar with various measuring instruments and would learn the importance of accuracy of measurements.*

At least 05 experiments from the following:

1. Measurements of length (or diameter) using Vernier calipers, screw gauge and travelling microscope.
2. To study the motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.

6. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
7. To determine the value of g using Bar Pendulum.
8. To determine the spring constant by Hooke's law

Texts/References:

1. Engineering Practical Physics, S Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
2. Practical Physics, G L Squires, 2015, 4^{th} Edition, Cambridge University Press
3. A Text Book of Practical Physics, I Prakash & Ramakrishna, 11^{th} Edn, 2011, Kitab Mahal

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PH125-MATHEMATICAL PHYSICS

Credits-03 (3-0-0)

Course objectives:

- Master multivariable calculus and Fourier series.
- Solve differential equations using Frobenius and understand special functions.
- Apply Beta/Gamma functions and solve PDEs.
- Understand and apply complex analysis.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials, Integrating factor, with simple illustration, Constrained Maximization using Lagrange Multipliers, **Fourier Series**: Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, Even and odd functions and their Fourier expansions, Application, Summing of Infinite Series.

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance, Frobenius method and its applications to differential equations, Legendre, Bessel Differential Equations, Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality, Simple recurrence relations.

Some Special Integrals: Beta and Gamma Functions and Relation between them, Expression of Integrals in terms of Gamma Functions.

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry, Solution of 1D wave equation. **Complex Analysis**: Brief Revision of Complex Numbers and their Graphical Representation, Euler's formula, De Moivre's theorem, Roots of Complex Numbers, Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions: poles and branch points, order of singularity, Integration of a function of a complex variable, Cauchy's Integral formula.

Texts/References:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier
2. Fourier Analysis, M R Spiegel, 2004, Tata McGraw-Hill
3. Essential Mathematical Methods, K F Riley and M P Hobson, 2011, Cambridge University Press
4. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
5. An Introduction to Ordinary Differential Equations, E A Coddington, 1961, PHI Learning
6. Differential Equations, George F Simmons, 2006, Tata McGraw-Hill

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PH 125L-MATHEMATICAL PHYSICS LAB

Credits: 01 (0-0-2)

Course objectives: *This laboratory would introduce students with the basic knowledge of scientific programming languages and implementation of C++/C/Scilab simulations for Mathematical Physics problems.*

At least 8 programs must be attempted from the following:

Introduction to C++: Introduction to Programming: Algorithms: Sequence, Selection and repetition, Structured programming, basic idea of Compilers, Data Types, Enumerated Data, Conversion and casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators, Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables.
C++ Control Statements and loops: if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Go to statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements.

Programmes:

1. To calculate area of a rectangle.
2. To check size of variables in bytes (Use of size of ( ) Operator).
3. To find roots of a quadratic equation.
4. To find largest of three numbers.
5. To check whether a number is prime or not.
6. To list Prime numbers up to 1000.
7. To find the sum and average of a list of numbers.
8. Program to check whether even or odd number.
9. To find the largest of a given list of numbers and its location in the list.
10. Sorting of numbers in ascending and descending order using Bubble sort, Sequential sort or Binary search.
11. To generate the Fibonnaci series.
12. To find the factorial of a number.

Texts/References:

1. Schaum's Outline of Programming with C++, J Hubbard, 2000, McGraw-Hill Pub
2. Numerical Recipes in C^{++}: The Art of Scientific Computing, W H Press et. al., 2^{nd} Edn., 2013, Cambridge University Press
3. An introduction to Numerical methods in C^{++}, Brian H. Flowers, 2009, Oxford University Press

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PH124-ELECTRICITY AND MAGNETISM

Credits-03 (3-0-0)

Course objectives:

- To learn and understand vector calculus.
- Understand the concepts of electrostatics and dielectrics.
- Apply laws of magnetism and understand magnetic materials.
- Learn electromagnetic induction and Maxwell's equations

Vector Analysis: Vector algebra (Scalar and Vector product), gradient, divergence, Curland their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem (statement only).
Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics, Applications of Gauss theorem, Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor, Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere, Calculation of electric field from potential, Capacitance of an isolated spherical conductor, Parallel plate, spherical and cylindrical condenser, Energy per unit volume in electrostatic field, Dielectric medium, Polarisation, Displacement vector, Gauss's theorem in dielectrics, Parallel plate capacitor completely filled with dielectric.

Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current, Divergence and curl of magnetic field, Magnetic vector potential, Ampere's circuital law, Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility,

Brief introduction of dia-, para- and ferro-magnetic materials.
Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils, Energy stored in magnetic field, Introduction to Maxwell`s equations.

Texts/References:

1. Vector analysis – Schaum's Outline, M R Spiegel, S Lipschutz, D Spellman, 2nd Edn., 2009, McGraw- Hill Education
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
3. Electricity & Magnetism, J H Fewkes & J Yarwood. Vol. I, 1991, Oxford University Press
4. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole
6. Introduction to Electrodynamics, D J Griffiths, 3rd Edn, 1998, Benjamin Cummings

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PH 124L-ELECTRICITY AND MAGNETISM LAB

Credits: 01 (0-0-2)

Course objective: *The laboratory content compliments the theoretical knowledge of Electricity and Magnetism and henceforth, gives hands-on experience. It also provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 05 experiments from the following:

1. Use a multimeter for measuring (i) Resistances, (ii) AC and DC Voltages, (iii) DC current, (iv) Capacitances, and (v) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Carey Foster's bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx).
6. To determine self-inductance of a coil by Anderson's bridge.
7. To study response curve of a Series LCR circuit and determine its (i) Resonant frequency, (ii) Impedance at resonance, (iii) Quality factor Q and (iv) Band width.
8. Determine a high resistance by leakage method using Ballistic Galvanometer.
9. To determine the specific resistance of a wire or unknown capacitance by Wien's bridge.
10. To determine the magnetic field along the axis of the current carrying coil and estimate the radius of coil using Tangent Galvanometer.

Texts/References:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S Panigrahi and B Mallick, 2015, Cengage Learning

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PH126-WAVES AND OPTICS

Credits-03 (3-0-0)

Course objectives:

- To be able to analyze oscillations and wave motion.
- Understand sound, light waves, and Huygens' principle.
- To study interference and diffraction.
- To learn about light polarization.

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM), Linearity and

Superposition Principle, (i) Oscillations having equal frequencies and (ii) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures (1:1 and 1:2) and their uses.
Waves Motion- General: Transverse waves on a string, Travelling and standing waves on a string, Normal Modes of a string, Group velocity, Phase velocity, Plane waves, Spherical waves, Wave intensity.
Sound: Sound waves, production and properties, Intensity and loudness of sound, Decibels, Intensity levels, General idea of musical notes and musical scale, Acoustics of buildings (General idea).
Wave Optics: Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle.

Interference: Interference: Division of amplitude and division of wavefront, Young's Double Slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films, Newton's Rings: measurement of wavelength and refractive index.

Diffraction: Fraunhofer diffraction- Single slit, Double Slit, Multiple slits and Diffraction grating, Fresnel Diffraction: Half-period zones, Zone plate, Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.
Polarization: Transverse nature of light waves, Plane polarized light–production and analysis, Circular and elliptical polarization (General idea).

Texts/References:

1. Vibrations and Waves, A P French, 1st Ed., 2003, CRC press
2. The Physics of Waves and Oscillations, N K Bajaj, 1998, Tata McGraw Hill
3. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill
4. Principles of Optics, B K Mathur, 1995, Gopal Printing
5. Fundamentals of Optics, A Kumar, H R Gulati and D R Khanna, 2011, R. Chand Publications
6. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley
7. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

PH 126L-WAVES AND OPTICS LAB

Credits: 01 (0-0-2)

Course objectives: *The laboratory content compliments the theoretical knowledge of Waves and Optics and gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 05 experiments from the following:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To determine the frequency of AC mains using Sonometer.
3. To study Lissajous figures.
4. Familiarization with: Schuster's focusing, determination of angle of prism.
5. To determine refractive index of the material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine wavelength of sodium light using Fresnel biprism.
8. To determine wavelength of sodium light using Newton's rings.
9. To study interference and diffraction pattern with slits.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

Texts/References:

1. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

3. A Laboratory Manual of Physics for undergraduate classes, D P Khandelwal,1985, Vani Pub.

PH227- THERMAL PHYSICS AND STATISTICAL MECHANICS
Credits-03 (3-0-0)

Course objectives: *The objective of the course is to understand and apply the Zero/First/Second laws and Maxwell thermodynamics equations to solve problems of macroscopic systems in thermal equilibrium. It will also give basic knowledge of Heat engines, and exposure of Kinetic theory of gases, transport phenomenon involved in ideal gases, phase transitions and behavior of real gases. This course provides elementary and applied Statistical Mechanics for exploring the Bose-Einstein statics, Fermi-Dirac statics, Relativistic Fermi-Gas, Black body radiation, Stefan-Boltzmann law etc.*

Laws of Thermodynamics: Thermodynamic Description of system: Zero'th Law of thermodynamics and temperature, First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot's cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.
Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for ($C_P – C_V$), C_P/C_V, TdS equations.
Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases.

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law &Wien's displacement law from Planck's law.
Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity – Quantum statistics –Macrostate and Microstate – Entropy and Thermodynamic Probability - Phase space - Fermi-Dirac distribution law - Bose-Einstein distribution law - photon gas - comparison of three statistics.

Texts/References:

1. Thermal Physics, S Garg, R Bansal and C Ghosh, 1993, Tata McGraw-Hill
2. A Treatise on Heat, Meghnad Saha, and B N Srivastava, 1969, Indian Press
3. Heat and Thermodynamics, M W Zemasky and R Dittman, 1981, McGraw Hill
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F W Sears and G L Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole
6. Thermal Physics, A Kumar and S P Taneja, 2014, R. Chand Publications

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PH 229-ELEMENTS OF MODERN PHYSICS
Credits-03 (3-0-0)

Course objectives:
- To learn about and understand the basic concepts of quantum mechanics
- Apply quantum mechanics to atoms and phenomena.
- Learn about nuclear structure, forces, and radioactivity.

Quantum theory of wave and particle: Planck's quantum, Planck's constant and light as a collection of photons, Photo-electric effect and Compton scattering, de Broglie wavelength and matter waves, Davisson-

Germer experiment.

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra, Bohr's quantization rule and atomic stability, calculation of energy levels for hydrogen like atoms and their spectra, Position measurement- gamma ray microscope thought experiment, Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory, Estimating minimum energy of a confined particle using uncertainty principle, Energy-time uncertainty principle,

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

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

Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in nucleus as a consequence of the uncertainty principle, Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.

Radioactivity: Stability of nucleus, Law of radioactive decay, Mean life and half-life, □ decay, □□decay - energy released, spectrum and Pauli's prediction of neutrino, □-ray emission.

Texts/References:

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, J R Taylor, C D Zafiratos, M A Dubson,2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics, Vol.4. E H Wichman, 2008, Tata McGraw-Hill Co.
5. Modern Physics, R A Serway, C J Moses, and C A Moyer, 2005, Cengage Learning

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PH 229L-ELEMENTS OF MODERN PHYSICS LAB

Credits 01 (0-0-2)

Course objectives: *This laboratory provides the theoretical knowledge of Modern Physics and gives hands-on experience. Students will learn how to measure different universal constants with several experiments. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 05 experiments from following:

1. Measurement of Planck’s constant using black body radiation and photo-detector.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the Planck’s constant using LEDs of at least 4 different colours.
4. To determine the wavelength of H-alpha emission line of Hydrogen atom.
5. To determine the ionization potential of mercury.
6. To determine the value of e/m by (i) Magnetic focusing or (ii) Bar magnet.
7. To setup the Millikan oil drop apparatus and determine the charge of an electron.
8. To show the tunneling effect in tunnel diode using I-V characteristics.

Texts/References:

4. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
5. Advanced level Physics Practical, Michael Nelson and Jon M Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
6. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11^{th}Edn, 2011, Kitab Mahal