B. Sc. Physics (Honours)

Program under UGC- LOCF & CBCS

(*Effective from Academic Year 2020-21*)

Department Physics & Mathematics
Faculty of Science

Sri Sri University

Sri Sri Vihar, Bidyadharpur Arilo
Ward No-3, Cuttack-754006

Aims of the program:

The aims and objectives are to

1. create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at +2 level and to motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.
2. learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
3. develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.
4. expose the student to the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature spanning from 10^{-15} m to 10^{26} m in space and 10^{-10} eV to 10^{25} eV in energy dimensions.
5. emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.
6. emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

In view of opening the new windows in higher education and research and opening job opportunities at all levels from technicians to innovator scientists and engineers, two undergraduate programs are offered in our universities and other higher education institutions (HEI) at the entry level of our higher education system.

Program Learning Outcomes:

The student graduating with the Degree B.Sc (Honours) Physics should be able to

1. Acquire

(i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

(ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

(iii) skills in areas related to one's specialization area within the disciplinary/subject area of Physics and current and emerging developments inthe field of Physics.

2. Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
3. Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

4. Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.
5. Demonstrate relevant generic skills and global competencies such as

(i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary- area boundaries;

(ii) investigative skills, including skills of independent investigation of Physics-related issues and problems;

(iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;

(v) ICT skills;

(vi) personal skills such as the ability to work both independently and in a group.

6. Demonstrate professional behavior such as

(i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

(ii) the ability to identify the potential ethical issues in work-related situations;

(iii) appreciation of intellectual property, environmental and sustainability issues; and

(iv) promoting safe learning and working environment.

General Rules & Regulations

Academic Session: Semester system. 02 semesters (July - December and January - May).

Medium of Instruction of the Program: The medium of instruction and examination shall be English for B.Sc. Physics Program.

Conduct of the Program: A student of the B.Sc. Physics Program shall not be permitted to seek admission concurrently to any other equivalent or higher degree or diploma examination in this University or any other University, subject to rules/regulations of UGC or equivalent body in this regard and adoption of the same by the University.

Attendance Rules: A student is required to attend 100% of the classes held in a course in the specific semester in order to be eligible to appear in the End-semester examination of that particular course. Waiving of attendance-deficit up to a maximum of 25% is permissible to accommodate following situations: (a) Representing the University in any inter-collegiate, inter-University, local, national or international events; (b) Participating in an activity of the University with prior permission of the

Competent Authority; (c) Participation in NCC/NSC/NSS Camps duly supported by certificate; (d) Participation in Educational Excursions, which form a part of teaching in any subject, conducted on working days duly certified by the concern Course Teacher/Head of Department /Dean; and (e) to cover all unforeseen reasons like illness, hospitalization, personal engagements elsewhere or other personal reasons which compel a student to absent herself/himself from attending the classes. Hence, it shall be mandatory/compulsory to every student to have attendance in 75% classes held in particular course. No waiver, for whatsoever reason, shall be given. Accordingly, no application requesting waiver below 75% attendance shall be entertained by the Department. The attendance of a newly admitted candidate shall be counted from the date of her/his admission/registration or date of beginning of classes, whichever is later. In the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, if a new student is admitted late after the commencement of the classes, s/he must get herself/himself registered in the desired courses following the due procedure within 6 working days after the admission failing which her/his attendance shall be counted after 6 working days from the date of admission.

Removal of Student Name from the Program: The name of a student falling under any one of the following categories shall automatically stand removed from the rolls of the University: (a) A student who has failed to fulfill the minimum grade point requirements prescribed for the Program during the maximum duration of the Program, (b) A student who has already exhausted the maximum duration allowed for completion of the Program and has not fulfilled the requirements for the award of the degree, (c) A student who is found to be involved in misconduct, forgery, indiscipline or any other objectionable conduct, upon recommendation of the Disciplinary Committee or any other procedure deemed fit by the University & (d) A student who has failed to attend the classes as stipulated under the clause of attendance requirements in this booklet.

Student Advisor/Mentor: The Department shall appoint an Advisor/Mentor for student(s) from amongst the members of the faculty concerned. All faculty members of the department shall function as Student Advisors/Mentors and shall have more or less equal number of students. The Student Advisor/Mentor shall advise the student in choosing courses and render all possible support and guidance to him/her.

Remedial and Additional Class: Remedial and additional classes/Lab. will be conducted as and when necessary.

Repeating Course(s): A student having attendance shortage in any course may repeat the course by taking re-admission in that course in subsequent odd/even semester(s), whenever the course is being offered, within the maximum permissible duration of the Program. If the student has fulfilled the attendance requirement but did not obtain the necessary grade to pass the paper, s/he will have to take all the examinations (Internal and End-Semester) afresh. In such case the course content shall be based on the syllabi of the course in force at the time of repeat of the course. The student needs to complete the formalities as per SSU/CoE rules and regulations before repeating the course(s).

Power to Relax and Amendments: All the above guidelines are subject to the amendments, as and when required, as per the decisions pertaining to rules, regulations and norms of the University Statutory Bodies and other Regulatory Bodies etc. from time to time.

Notwithstanding anything stated in the guidelines, for any unforeseen issues arising, and not covered by the guidelines, or in the event of differences of interpretation, the Vice-Chancellor may take a decision, after obtaining the opinion/advice, if required, Deans/HoDs/Registrar. The decision of the Vice-Chancellor shall be final.

Paper/Course Code: Each course offered by the Department of Physics and Mathematics is identified by a unique course code comprising of **seven letters / numbers** indicating Program/level of Program [first letter in uppercase, i.e., **B** for **B**achelor (Under Graduate) and **M** for **M**aster (Post Graduate)], Discipline/Subject (Next two letters in uppercase, i.e., **PH** for PHysics), Semester (next digit starting from 1), Course Number (next two digits starting from 01 for each semester).
For example, the course code of the second paper of B.Sc. Physics Honors Program in the Third semester in the Department will be **BPH302**.
Every time when a new course is prepared by the Board of Studies (BoS) of the Department it shall be assigned a new course code. However, the University may decide a different course codification pattern for any Programme in future as per the demand of the situation.

Abbreviation: DSE: Discipline Specific Elective; GE: Generic Elective; AECC: Ability Enhancement Compulsory Course; AEECSB: Ability Enhancement Elective Course (Skill Based); ECA: Extra Curricular Activities. Core Course implies Physics.

Qualifying Marks: Pass Mark (P): 50 points each paper.

Credit System: Theory: 01 hour lecture = 01 credit, **Lab./Practical**: 02 hours = 01 credit (2 credits = 2 x 2 = 4 hrs.), **Tutorial**: 01T = 1 hr.

Distribution of Points: Theory (T) = 100 points, Practical (P) = 100 points,

Distribution of points - Theory: *Class tests*: 40 points (2 x 15 + 10 = 40); *End-Term*: 60 points

Distribution of points - Practical: *Class tests*: 40 points (2 x 20 = 40); *End-Term*: 60 points

[Distribution of points of Practical *Class tests*: Exam: 10 points, Viva: 05 points, Overall record up to that test (Write-up and on time submission): 05 points]

[Distribution of points of Practical *End-Term*: Exam: 40 points, Viva: 10 points, Overall record (Write-up and on time submission throughout the semester): 10 points]

NOTE: Numerical Computation: Total points 100 including theory and lab. session. Class tests = 40 points. Class test includes both theory and practical. Final/end term paper will carry 60 points and will be based on theory.

Examination Question Pattern:

(i) Objective/Multiple choice questions (Any number of options may be correct. Points will be awarded if all the correct answers are marked).
(ii) Explanation/Reasoning/Analytical thinking.
(iii) Problem/Numerical.
(iv) Discussion/Note.
(v) Derivation.
(vi) As decided by course instructor.

Extracurricular activities (ECA)/Minor projects are incorporated as per UGC guidelines. There will be no exam(s) . Points will be given based on the performance of the student.

Assessment of minor project**:** The minor project paper shall be assessed on the basis of the contents of the report submitted by students and its presentation, equally. The assessment will be made by the concerned teacher/advisor/supervisor.

The distribution of weightage for the valuation of semester-long major project work/ dissertation/ reading course/project shall be:

(i) Periodic presentation:	30%
(ii) Report (Progress & Final):	40%
(iii) Final Presentation & Viva voce:	30%

DSE-1, DSE-2, DSE-3, and DSE-4 are from Physics. DSE-1: Atomic & Molecular Physics, DSE-2: Semiconductor Physics and Devices, and DSE-3 and DSE-4 are Physics specific advanced elective papers. All four are compulsory.

There are four SEC papers. SEC-1 (Computation Physics) and SEC-2 (Instrumentation) are from Physics, SEC-3 (Number Theory) and SEC-4 (Graph Theory or Applied Optics or Radiation Safety). All four are compulsory.

There are two GE papers, each from Mathematics and Computer Science in the semester I and II. One GE paper from Mathematics each in Semester III and IV. Two AECC papers, AECC-1: Environmental Science and AECC-2: English Communication are compulsory and to be completed in the first year.

Syllabus

B. Sc. Honours in Physics @ SSU - Semester Wise Course Structure

Nature of Course	Course Code	Course Title	Credits			Total Points
		Semester - I	**L**	**T**	**P**	
Core Course	BPH101	Mathematical Physics - I	4	0	0	100
Core Course	BPH102	Mechanics-I	4	0	0	100
Core Course	BPH103	Physics Lab. - I	0	0	4	100
GE(Maths.)	BPH104	Calculus	5	1	0	100
GE (CS)	BPH105	Programming using C	4	0	0	100
GE (CS)	BPH106	Programming using C Lab.	0	0	2	100
AECC	BPH107	Environmental Science	4	0	0	100
		Total Credits and Points of Semester - I	**28**			**700**
		Semester - II	**L**	**T**	**P**	
Core Course	BPH201	Electricity & Magnetism	4	0	0	100
Core Course	BPH202	Waves & Optics	4	0	0	100
Core Course	BPH203	Physics Lab. - II	0	0	4	100
GE(Maths.)	BPH204	Integral Calculus & Differential Equations	5	1	0	100
GE (CS)	BPH205	Object Oriented Programming	4	0	0	100
GE (CS)	BPH206	Object Oriented Programming Lab.	0	0	2	100
AECC	BPH207	English Communication	4	0	0	100
Total Credits and Points of Semester -II			**28**			**700**
		Semester - III	**L**	**T**	**P**	
Core Course	BPH301	Mathematical Physics – II	4	0	0	100
Core Course	BPH302	Thermal Physics	4	0	0	100
Core Course	BPH303	Analog Systems & Applications	4	0	0	100
Core Course	BPH304	Physics Lab. - III	0	0	4	100
GE(Maths.)	BPH305	Real Analysis	5	1	0	100
SEC-1	BPH306	Computational Physics	0	0	2	100
Total Credits and Points of Semester - III			**24**			**600**
		Semester - IV	**L**	**T**	**P**	
Core Course	BPH401	Mathematical Physics - III	4	0	0	100
Core Course	BPH402	Elements of Modern Physics	4	0	0	100
Core Course	BPH403	Digital Systems & Applications	4	0	0	100
Core Course	BPH404	Physics Lab. - IV	0	0	4	100
GE(Maths.)	BPH405	Algebra	5	1	0	100
SEC-2	BPH406	Instrumentation	0	0	2	100
Total Credits and Points of Semester - IV			**24**			**600**

		Semester - V	**L**	**T**	**P**	
Core Course	BPH501	Quantum Mechanics & Applications	4	0	0	100
Core Course	BPH502	Solid State Physics	4	0	0	100
Core Course	BPH503	Physics Lab. - V	0	0	4	100
DSE-1	BPH504	Atomic & Molecular Spectroscopy	4	0	0	100
DSE-2	BPH505	Semiconductor Physics and Devices	4	0	0	100
SEC-3 (Maths.)	BPH506	Number Theory	2	0	0	100
Total Credits and Points of Semester - V			**22**			**600**
		Semester - VI	**L**	**T**	**P**	
Core Course	BPH601	Electromagnetic Theory	4	0	0	100
Core Course	BPH602	Statistical Mechanics	4	0	0	100
Core Course	BPH603	Physics Lab. - VI	0	0	4	100
DSE-3	BPH6XX	Elective 1	4	0	0	100
DSE-4	BPH6XX	Elective 2	4	0	0	100
SEC-4 (Any one)	BPH604	Graph Theory *or*	2	0	0	100
	BPH605	Applied Optics *or*	0	0	2	
	BPH606	Radiation Safety	2	0	0	
Total Credits and Points of Semester - IV			**22**			**600**
TOTAL CREDIT HOURS and POINTS			**148**			**3800**

Physics Syllabus

Semester - I

Mathematical Physics - I

Course Objectives: Provide mathematical knolwedge required for physics

1. Vectors, dot and cross product, properties, del operator, gradient of a scalar function, divergence, & curl of a vector, Laplacian operator, line, surface, & volume integrals, projection of a vector.
2. Components of a vector, Gauss divergence theorem, Green's theorem, Stokes theorem.
3. Rotational & irrotational vectors; solenoidal vectors.
4. Conservative force field.
5. Spherical and cylindrical coordinates.
6. Gamma and beta functions.
7. Kronecker delta, Levi-Civita symbol, error function, step function, unit function.
8. Concept of matrices and error analysis.

Learning Outcomes: After completion of the course, learners will be able to

1. Apply the concept of vector calculus in physics and other branches of science (mechanics, electricity, amgentism, electrodynamics, quantum mechancis).
2. Answer and solve conceptual questions and problems.
3. Apply the concept of spherical and cylindrical coordinates in physics.
4. Concepts in other mathematical/computational physics.

Vector Calculus: Properties of vectors under rotations, scalar product and its invariance under rotations, vector product, projection, scalar triple product and their interpretation in terms of area and volume respectively, scalar and vector fields, 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, velocity & acceleration, tangential & normal component of velocity & acceleration, vector identities, ordinary integrals of vectors, Jacobian, flux of a vector field, Gauss' divergence theorem, Green's and Stokes theorems and their applications (no rigorous proofs), potential energy, relation between force and potential, work-energy theorem, conservative, non-conservative, rotational & irrotational fields.

Orthogonal Curvilinear Coordinates: Spherical and cylindrical coordinate systems, multiple integrals in different coordinate systems (cartesian, spherical, and cylindrical), orthogonal curvilinear coordinates, derivation of gradient, divergence, curl and Laplacian in cartesian, spherical and cylindrical coordinate systems.

Some Special Functions: Beta function, Gamma function, Dirac delta function (definition, representation as limit of a Gaussian function and rectangular function and properties), Kronecker delta, Levi-Civita symbol, error function, step function, unit function.

Theory of Errors: Systematic and Random Errors, propagation of errors, normal Law of errors, standard and probable error, least-squares fit, error on the slope and intercept of a fitted line.

Matrices: Concepts of matrices, their representations, inverse [n x n].

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Mathematical Methods for Physicists – G. Arfken & H. Weber, Elsevier Academic Press.
2. Mathematical Physics – H.K. Das, S. Chand.
3. Higher Engineering Mathematics – B.S. Grewal.
4. Schaum's outline of Theory & Problems of Vector Analysis and an introduction to Tensor Analysis - Murray R. Speigel, McGraw Hill.
5. Mathematical Methods in the Physical Sciences – M. Boas.
6. Mathematics for Physicists & Engineers – Pipes.
7. The Use of Integral Transforms – I.N. Sneddon.
8. A Text Book of Mathematical Physics – S. Chandra.
9. Mathematical Physics – H.K. Dass & R. Verma, S. Chand.
10. Mathematical Physics – P.K. Chattopadhyay.
11. Mathematical Methods for Scientists & Engineers – D.A. McQuarrie.
12. Essential Mathematical Methods – K.F. Riley & M.P. Hobson.
13. Mathematical Physics – Goswami, Cengage Learning.
14. Mathematical Physica and Special Relativity – M. Das, P.K. Jena, & B.K. Dash, Srikrishna Prakashan, 2nd edition.
15. Mathematical Physics – C. Harper, Prentice.
16. Advanced Engineering Mathematics – E. Kreyszig, Wiley India.
17. Advance Engineering Mathematics – D.G. Zill & W.S. Wright, Jones & Bartlett Learning.

Mechanics - I

Course Objectives:

1. Provide knowledge of inertial and non-inertial reference frames, conservative and non-conservative forces, various types of friction, system of particles, rotational motion, and gravitation, gravitation, work-energy theorem, elasticity, moment of inertia.
2. Acquaint students with the basic concept of fluid dynamics – viscosity & surface tension.

Learning Outcomes: After completion of the course, learners will be able to

1. Apply the concept of conservation of linear momentum, energy and angular momentum in various classical systems.
2. Answer questions and solve problems related to
   i. System of particles, rotational motion, gravitation.
   ii. Central forces including Keplar problems.
   iii. Rigid body.
   iv. Moment of inertia of various bodies.

Newtonian Mechanics: Dimensional analysis, inertial & Non-inertial frames of reference, Newton's laws of motion, momentum & impulse, kinetic energy, motion of connected bodies and pulley (Atwood's Machine etc,), free body diagram, friction-static, kinetic, & rolling friction, coefficient of static & kinetic friction, angle of repose, motion of a body on frictional surface & inclined plane, work done by frictional force, methods of reducing friction, elastic & in-elastic collisions in one & two dimensions, projectile motion, rocket (variable mass) motion.

Work, Power, & Energy: Concepts of work, power, & work-energy theorem, path independence of work, conservative & non-conservative force field, relation between force and potential energy ($\vec{F}=-\nabla V$), potential energy diagram-understanding the potential curve – stable/unstable equilibrium, Hooke's law & spring-mass system – work done *on/by* the system, elastic potential energy, work & energy with varying force.

System of Particles: Discrete & continuous system, density-surface, volume, & linear density, Degrees of Freedom (DoF), Center of Mass (CM) & Center of Gravity (CG), moment of a force-concept of torque, momentum of a system of particles, motion of the CM, conservation of momentum, angular momentum of a system of particles, external torque acting on the system, relation between torque & angular momentum, conservation of angular momentum, relation between angular impulse & angular momentum, kinetic & potential energy of a system of particles, conservation of energy, motion relative to CM, calculation of centroid of various bodies, various cases such as motion of a point mass tied to the string wound on a cylinder, solid cylinder rolling down without slipping on an inclined plane.

Rotational Motion: Angular velocity and angular acceleration, rotation with constant angular momentum, linear and angular variables, conservation of angular momentum, kinetic energy of rotation, moment of inertia, parallel and perpendicular axis theorem of moment of inertia, calculation of moment of inertia of objects of various shapes (e,g,, rod, sphere, cylinder etc,), torque, relation between torque and angular acceleration, work-energy theorem in rotational motion, angular acceleration and steady precession, product of inertia, Euler's equation of motion, Euler angles, motion of a spinning top, Gyroscopes.

Gravitation: Motion in a uniform field – freely falling bodies & projectiles, Newton's law of universal gravitation, acceleration due to gravity, mass & density of earth, concept of weight & apparent weight inside of a moving elevator, variation of gravity due to depth/height, conservation of mechanical energy – only gravitational forces & forces other than gravitational one, variation of time period of simple pendulum due to altitude, statics in a uniform gravitational field, gravitational field & potential/potential energy, determination of gravitational field/potential of various systems, motion in a resisting medium, Gyroscopic motion.

Elasticity: Concept of elastic and plastic bodies, Hooke's law and elastic limit, stress and strain, Young's modulus, bulk modulus, axial modulus, modulus of rigidity, Poisson's ratio, relation between elastic constants, thermal stress, work done in stretching a wire, stress-strain diagram-strength, elasticity, & plasticity, torsion of a cylinder, bending of beams-cantilever, spiral springs, elasticity of fluids, effect of temperature & pressure on elasticity, compressibility of gases, isothermal & adiabatic elasticities, understanding the theory of elasticity (principle strains and principle of superposition), strain ellipsoid.

Fluid Mechanics: Fluid flow: Compressible & incompressible fluid, steady, streamline, laminar, & turbulent, rotational & irrotational flow, Continuity equation, Bernoulli's equation, applications (i,e,, speed of efflux/Torricelli's law, atomizer or sprayer, Bunsen's burner, blowing off of a roof, blood flow & heart attack, motion of a spinning ball/Magnus effect, filter pump/aspirator, attraction between two closely parallel moving boats etc,) and limitations of Bernoulli's principle, Venturimeter.

Viscosity: Concept of viscosity, fugitive elasticity, Poiseulle's formula and corrections to Poiseulli's formula, Stokes' law, terminal & critical velocity, Reynold's number, effect of temperature and pressure on viscosity, viscosity of very viscous liquids, damping due to viscosity, viscosity of colloidal solution, materials intermediate between liquids & solids, non-Newtonian (complex or Bingham Plastic solid), visco-elastic (plasto-elastic solid) and visco-inelastic (plasto-elastic solid) liquids, flow of a compressible fluid (i,e,, gases) through a narrow tube, viscosity of gas, effects of pressure & temperature on viscosity of gases, solid friction and lubrications, applications of viscosity.

Surface tension: Basic concept of surface tension, molecular theory, surface energy & surface tension, cohesion & adhesion, angle of contact and shape of liquid drops and meniscus in a narrow tube, contact angle and wetting, pressure difference across a curved liquid surface (plane, concave and convex), various cases of excess pressure inside a liquid drop or bubble, force between two plates separated by a thin liquid layer, rise or fall of liquids in capillary tubes (Ascent formula), rise of liquid in a capillary tube of insufficient length, factors affecting surface tension (i,e,, temperature, impurities, liquid density etc,), surface tension and ripples, liquid-liquid interface, applications, surface tension of solution, surface tension and evaporation, spreading of films on liquids (primary and secondary spreading).

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Sears & Zemansky's University Physics with Modern Physics – H.D. Young, R.A. Freedman, & A.L. Ford, Pearson.
2. Fundamentals of Physics – D. Halliday, R. Resnick, & J. Walker.
3. University Physics – H. Bension, John Wiley & Sons.
4. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett, Thomson.
5. Essential University Physics – R. Wolfson, Addison-Wesley.
6. Understanding Physics – M. Mansfield & C. O'Sulliban, Wiley.
7. Physics for Scientists & Engineers with Modern Physics – Giancoli
8. Conceptual Physics – P.G. Hewitt, Pearson.
9. Physics for Scientists & Engineers with Modern Physics – P.M. Fisbane, S.G. Gasiorowicz, & S.T. Thornton, Pearson.
10. Physics for Scientists & Engineers – P. Tipler.
11. College Physics – F.J. Bueche & E. Hecht (Schaum's Outline).

12. Theory and Problems of Theoretical Mechanics – M.R. Spiegel, McGraw Hill (Schaum's Outline Series).
13. The General Properties of Matter – F.H. Newman & V.H.L. Searle, Radha Publishing House, Calcutta.
14. Fundamentals of Fluid Mechanics – Bruce R. Munson, Alric P. Rothmayer, Theodore H. Okiishi, Wade W. Huebsch, Wiley.
15. Classical Mechanics: An Undergraduate Text; Classical Mechanics – R. Douglas Gregory, Cambridge Univ. Press.
16. Classical Mechanics – V.K. Jain, Ane Books Pvt. Ltd.
17. Classical Mechanics – N.C. Rana & P.S. Joag, TMH.
18. An Introduction to Mechanics – Daniel Kleppner & Robert Kolenkow, CUP.
19. Analytical Mechanics – G.R. Fowles & G.L. Cassidy, Cengage Learning.
20. University Physics – Ronald Lane Reese, Thomson Brooks/Cole.
21. Mechanics – R.N. Mishra, Kedar Nath & Ram Nath Publication.
22. Analytical Mechanics – G.R. Fowles & G.L. Cassiday, Cengage Learning.
23. An Introduction to Mechanics – D. Kleppner & R.J. Kolenkow, McGraw Hill.

Physics Lab. – I

Course Objectives:
1. Verify physical laws through experiments.
2. Provide hands-on training on various PC and non-PC based instruments.
3. Make 'Learning-While-Doing' a realistic process.
4. Provide knowledge on various hardware (DAQ, interface) and software (instrument controlling software) related to experiments.
5. Impart necessary technical skills to understand, handle, design, & trouble-shoot devices & experimental set-ups.

Learning Outcomes: After completion of the course the learners will
1. Have
   i. Better understanding of the underlying principles of various physical phenomena.
   ii. Knowledge of various hardware and software components.
2. Be able to
   i. Handle various equipments.
   ii. Analyze data using Origin software.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours. Students should be taught Units, Dimensional & Error Analysis **(**standards & units, significant figures, estimates & order of magnitudes, dimensional analysis, uncertainty, & types of errors) in first two during lab. hours]

1. Experiments with linear track - Newton's laws of motion.
2. Rotational motion & Moment of inertia.
3. Ballistic Pendulum & Variable 'g' pendulum,

4. Spring-mass system
5. Projectile motion.
6. Friction.
7. Surface tension.
8. Viscosity.
9. Roller coaster & Work-energy theorem.
10. Contact angle.
11. Non-Linear Dynamics & Chaos

List of recommended books for practical:

1. Error Analysis – J.R. Taylor.
2. A practical guide to data analysis for physical science students – L. Lyons, Cambridge University Press.
3. Practical Physics – G.L. Squires, Cambridge University Press.
4. Experimental Physics – G. Prakash, Studium Press Pvt. Ltd.
5. Advanced Practical Physics for Students – B.L. Flint & H.T. Worsnop, Asia Publishing House.
6. Advanced Level Physics Practicals – M. Nelson & J.M. Ogborn, Heinemann Educational Publ.
7. Engineering Practical Physics – S. Panigrahi & B. Mallick, Cengage Learning India Pvt. Ltd.

Semester - II

Electricity and Magnetism

Course Objectives:

1. Acquaint students with the basic concept of electrostatics, current electricity, current density, continuity equation, magnetostatics, boundary value problems & special techniques, electromagnetic induction.
2. Provide in-depth knowledge of electromagnetic waves, potentials, fields, and radiation and their various applications in transmission and communication process.
3. Create thinking ability of applying the concept of electrostatics and magnetostatics in various media.

Learning Outcomes: After completion of the course, learners will

1. Have in-depth understanding of relevant topics.
2. Be able to
   i. Answer conceptual questions of electrostatics & magnetostatics.
   ii. Apply concept in understanding properties (electrical, thermal and optical) of various media.
   iii. Design electrical circuits.
   iv. Understand
      a) Articles related to electric and magnetic fields.

b) Nature of wave propagation in any medium.

v. Solve

a) Conceptual problems related to electrostatics & magentistics.

b) Boundary value problems in electrostatics & magentostatics.

c) Laplace's equation in one-, two-, & three-dimensional coordinate systems.

Electrostatics: Coulomb's law: Quantization and conservation of electric charges, Coulomb's law, Coulomb's law and gravitational force of attraction, electric field and filed lines, principle of superposition, discrete and continuous charge distributions.

Gauss's law: Electric flux, integral and differential form of Gauss's law and its application, line, surface, and volume charge density, electric potential and equipotential surface, curl of **E**, relation between field and potential, Energy due to system of point charges, Poisson and Laplace's equations, boundary conditions, electric field and potential due to continuous/discrete charge distribution, work & energy in electrostatics, conductors and their basic properties, induced charges.

Boundary value problems: Laplace's equation in one, two, and three dimensional rectangular coordinates, boundary conditions and uniqueness theorems, method of images (brief discussion).

Electric dipole: Basic concept of field and potential of monopole, dipole, quadrupole, and octupole, detailed study of electric dipole (field and potential of a dipole, force and torque on a dipole, potential energy of a dipole, dipole-dipole interactions/potential energy between two dipoles).

Capacitors: Parallel plate, spherical, and cylindrical capacitors, series and parallel combination of capacitor, energy stored in capacitor, Child-Langmuir law (without derivation).

Electric field in matter: Polarization, alignment of polarized molecules, Induced dipoles, field due to polarized object, concept of dielectric field inside a dielectric, capacitor with dielectric, Gauss's law in dielectrics, dielectric constant, energy density of an electrostatic field (with and without dielectric), polarizability, permittivity, and susceptibility, dielectric breakdown, capacitor with dielectric medium.

DC and AC networks: DC Network: Definition of current, current density as a vector field, equation of continuity, surface current density, Ohm's law, Ohmic and non-Ohmic regions, resistances, capacitors, inductors, voltage and current sources, series and parallel connections, voltage divider, power, spherically symmetric current distribution, nonuniform distributions of current density, consideration, Kirchhoff's voltage and current Law (KVL & KCL), applications of KVL and KCL (node and loop methods, reciprocity theorem, principle of superposition, Thevenin's theorem), potentiometer circuit, Wheatstone bridge, transient current, growth &decay in RC & LCR Circuits.
AC Network: Current voltage relation for sinusoidal voltages applied to resistance, capacitance and inductance, reactance and impedance, phasors, complex representation of voltages and currents, power in AC circuits, rms values, power factor, LR and CR circuits, series and parallel LCR circuits, resonance.

Magnetostatics: Biot-Savart and Ampere's laws: Biot-Savart law and its application, integral and differential form of Ampere's law, definition of Ampere, **B** near a long wire, circular loop and Helmholtz coils, force between two parallel conductors, magnetic induction inside a conductor, magnetic dipole, interaction between two magnetic dipoles, Gyromagnetic ratio, magnetic field of a solenoid and toroid, magnetic scalar and vector potential, concept of magnetic dipole (**m**)-current loop in a uniform magnetic field, potential energy of **m,** dipole-dipole interaction.

Magnetic properties of matter: Magentization vector (**M**), magnetic intensity (**H**), magnetic susceptibility & permeability, relation between **B**, **M**, & **H**, brief concept of various magnetism (para, ferro etc.), B-H curve, hysteresis.

Lorentz force: Lorentz force, charged particle in an electric field & magnetic field, cyclotron and cycloid motion, Hall effect.

Electromagnetic induction: Lenz's law, Faraday's law of electromagnetic induction, magnetic flux, motional emf, self and mutual inductance, self-inductance of solenoid, energy in magnetic field, transformer.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Sears & Zemansky's University Physics with Modern Physics – H.D. Young *et al*.
2. Fundamentals of Physics – D. Halliday, R. Resnick, & J. Walker.
3. University Physics – H. Bension, John Wiley & Sons.
4. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett, Thomson.
5. Essential University Physics – R. Wolfson, Addison-Wesley.
6. Understanding Physics – M. Mansfield & C. O'Sulliban, Wiley.
7. Physics for Scientists & Engineers with Modern Physics – Giancoli.
8. Conceptual Physics – P.G. Hewitt, Pearson.
9. Physics for Scientists & Engineers with Modern Physics – P.M. Fisbane, S.G. Gasiorowicz, & S.T. Thornton, Pearson.
10. Physics for Scientists & Engineers – P. Tipler.
11. Electricity & Magnetism – A.S. Mahajan & A.A. Rangwala, Tata McGraw Hill.
12. Introduction to Electrodynamics – David J. Griffiths, PHI.
13. Electricity & Magnetism – D. Chattopadhyay & P.C. Rakshit, New Central Book Agency P. Ltd., Kolkata.
14. Electricity & Magnetism – E.M. Purcell, McGraw Hill.
15. Element of Electromagnetics – M.N.O. Sadiku, OUP.
16. Electricity & Magnetism – J.H. Fewkes & J. Yarwood, OUP.
17. Foundations of Electromagnetic Theory – J.R. Reitz, F.J. Milford, & R.W. Christy, Pearson.
18. Feynman lectures.

Waves and Optics

Course Objectives: To impart knowledge of
1. SHM, superpositions of two SHMs, Lissajous figure.
2. Oscillations – free, damped, & forced.

3. Speed of sound waves, interference of waves, Beats, Doppler Effect, & shock waves.
4. Reflection and refraction and geometrical optics.
5. Fermat's and Huygens's principles and their applications.
6. Interference and diffraction of light.
7. Fundamentals of laser – emission, absorption, and Einstein A & B Co-efficients.
8. Pumping (optical, electrical), population inversion, optical feedback.
9. Laser rate equation.

Learning Outcomes: After going through the course, students will be able to

1. Answer and solve conceptual and challenging questions and problems on waves, damped oscillation, forced oscillation, interference, diffraction, and polarization.
2. Answer and solve questions and problems related to interference and diffraction of light.
3. Understand
    i. Various optical phenomena, principles, workings, and applications of optical instruments.
    ii. Spontaneous and stimulated emission of radiation, optical pumping and population inversion.
    iii. Basic lasing.
    iv. Various types of lasers in details and their applications.
3. Answer and solve geometrical optics, wave optics, & laser related questions and problems.
4. Handle sophisticated optical components.
5. Perform laser related experiments.
6. Pursue career in laser related atomic/fundamental and applied research and development.

Simple Harmonic Motion (SHM): Description of SHM (equation of motion, general solution) characteristics of SHM (amplitude, time period, phase, velocity, acceleration, potential energy and total energy of SHM), relation between linear SHM and uniform circular motion, some examples of SHM with one degree of freedom, superposition of SHMs (superposition of two collinear and two perpendicular SHMs having equal frequencies and different frequencies, Beats and Lissajous Figures).

Free Damped Oscillations: Introduction, damping forces, brief quantitative and qualitative description of damped oscillation of a system having one DoF (equation of motion, solution, large, critical &small damping, energy of a weakly damped oscillator, logarithmic decrement, relaxation time and Q-factor).

Forced Oscillations and Resonance: Introduction, brief quantitative and qualitative description of forced oscillation of a system having one degree of freedom (DoF) (equation of motion, solution, resonance), questions/exercises/problems.

Mechanical Waves: Types of mechanical waves, mathematical description of wave (i,e,, classical wave equation), speed of transverse wave, energy in wave motion, wave interference, boundary conditions, and superposition, standing waves in a string, normal modes of a string.

Sound and Hearing: Sound waves, speed of sound waves, sound intensity and decibal, standing sound waves & normal modes, resonance and sound, interference of waves and Beats, Doppler Effect, shock waves, Kevin's law.

Geometric Optics: Reflection and refraction of light: Reflection and refraction of light at plane and curved surfaces, mirror and lens formula, dispersion through prism, formation of rainbow (primary & secondary), photometry, radiant flux, solid angle, luminescence intensity, illumination/brightness, Lambert's cosine law, inverse square law for illumination, principle of photometry, & matrix methods in geometrical optics.

Human eye and optical instruments: Different parts of human eye, defects of vision and corrections, magnifier, microscopes and telescopes.

Wave Optics: Fermat's and Huygens's principles: Light is an electromagnetic spectrum, Fermat's principle and its application, Huygens's principle its application.

Interference: Young's experiment-coherence, intensity distribution and visibility of fringes, Fresnel's Biprism, Interference in thin films, Interference at an air wedge, Newton's rings, Michelson's interferometer.

Diffraction: Fraunhoffer and Fresnel Diffraction: Diffraction at a single slit, double slit, Diffraction by multiple slits, Diffraction grating, Resolving power- Rayleigh's criterion, Resolving power of a grating and telescope, Fresnel diffraction- half period zone, Zone plate, Diffraction at a circular aperture and at a straight edge (qualitative treatment only), Cornu's spiral.

Scattering of Light and Lasers: Scattering: A brief discussion on Tyndall, Rayleigh, and Raman scattering of light, Blue colour of the sky and ocean, a qualitative account of fluorescence and phosphorescence.

Introduction to Lasers: Spontaneous emission, absorption, and and stimulated emission, Einstein's A and B coefficients and relation between them, condition for amplification, population inversion, methods of optical pumping, energy level schemes of Ruby laser and He-Ne laser, properties and uses of lasers, basic concepts of hologram, discussion on the uses of holograms in daily life, recording and reproduction of holograms.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Waves and Oscillation – N.K. Bajaj, Tata McGraw-Hill.
2. Sears & Zemansky's University Physics with Modern Physics – H.D. Young, R.A. Freedman, & A.L. Ford, Pearson.
3. Fundamentals of Physics – D. Halliday, R. Resnick & J. Walker.
4. University Physics – H. Bension, John Wiley & Sons.
5. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett, Thomson.
6. Essential University Physics – R. Wolfson, Addison-Wesley.
7. Understanding Physics – M. Mansfield & C. O'Sulliban, Wiley.
8. Physics for Scientists & Engineers with Modern Physics – Giancoli.
9. Conceptual Physics – P.G. Hewitt, Pearson.

10. Physics for Scientists & Engineers with Modern Physics – P.M. Fisbane, S.G. Gasiorowicz, & S.T. Thornton, Pearson.
11. Physics for Scientists & Engineers – P. Tipler.
12. Introduction to the Physics of Waves – Tim Freegards, CUP.
13. Fundamentals of Optics – Jenkins & White, McGraw Hill.
14. Schaum's Outline Optics – Eugene Hecht, McGraw Hill.
15. Optics – Ghatak.
16. Laser Fundamentals – Silfvast, Cambridge University Press.
17. Fundamentals of Optics – F.A. Jenkins & H.E. White.
18. Lasers: Fundamentals & Applications – K. Thyagrajan & A.K. Ghatak.
19. Optical Physics – A. Lipson, S.G. Lipson, & H. Lipson.
20. Lasers & Non-linear Optics – B.B. Laud.
21. Principle of Lasers – O. Svelto.
22. Introduction to Optics – F.L. Pedrotti, L.M. Pedrotti, & L.S. Pedrotti.
23. Geometrical & Physical Optics – R.S. Longhurst, Orient Blackswan.
24. The Physics of Vibrations & Waves – H.J. Pain, John Wiley & Sons.
25. Mechanics – R.N. Mishra, Kedarnath & Ramnath.

Physics Lab. – II

Course Objectives:

1. Train to handle various instruments.
2. Verify laws through experiments.
3. Provide hands-on training on various PC and non-PC based instruments, make 'Learning-While-Doing' a realistic process, & knowledge on various hardware (DAQ, interface) and software (instrument controlling software) related to experiments.
4. Develop programing skills using software/programing language.

Learning Outcomes: After completion of the course learners will be able to

1. Analyze experimental results/data using Origin software.
2. Set-up optics experiment.
3. Handle sophisticated instrument.
4. Device/construct high power laser.
5. Do research in laser.
6. Pursue laser related fundamental and applied/industrial research in atomic & molecular physics, laser-matter interaction, and health sector.
7. Write computer code and solve problems related mechanics, electricity & magnetism, & modern physics.
8. To develop technical skills to design electronic circuits & devices.
9. To train to handle electronic components, devices.
10. To build necessary competency to trouble-shoot electronic devices.
11. To design and perform basic and applied research involving extensive electronic circuitry.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

1. Field lines & equipotential lines.
2. Ohm's law & Network theorem.
3. Effect of force in electric & magnetic fields.
4. Helmholtz coil.
5. Earth's magnetic field.
6. RC, LR, & LCR circuits.
7. Biot-Savart's & Faraday's law.
8. Self & mutual induction, induced emf, & Lenz's law.
9. Parallel & circular plate capacitor.
10. Refractive index, angle, and dispersive power of prism.
11. Wavelength of Na light by Newton's Rings & Fresnel Bi-prism.
12. Interference & diffraction.
13. Grating.
14. Damping & Coupling of oscillation.
15. Wavelength & velocity of sound & light.
16. Oscillation of a string.
17. Lens and mirrors.

Semester – III

Mathematical Physics - II

Course Objectives: Provide mathematical knolwedge required for physics
1. Fourier series.
2. Fourier and Laplace transforms.
3. Applications of Fourier & Laplace transformations in physics & other branches of science & technology.

Learning Outcomes: After completion of the course, learners will be able to
1. Apply the concept of Fourier transform in electronics, quantum mechanics, and other branches of science.
2. Transform various functions from one domain to another domain.
3. Concepts in other mathematical/computational physics

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, complex representation of Fourier series, expansion of functions with arbitrary period, expansion of non-periodic functions over an interval, even and odd functions and their Fourier expansions, applications, summing of infinite series, term-by-term differentiation and integration of Fourier series, Parseval's identity.

Integrals Transforms: Fourier transforms: Fourier Integral theorem, Fourier transform, examples, Fourier transform of trigonometric, Gaussian, finite wave train & other functions, representation of Dirac delta function as a Fourier integral, Fourier transform of derivatives, inverse Fourier transform, convolution theorem, properties of Fourier transforms (translation, change of scale, complex conjugation, etc,), three dimensional Fourier transforms with examples, application of Fourier transforms to differential equations (one dimensional wave and diffusion/heat flow equations), Gaussian function and transformation.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Mathematical Methods for Physicists – G. Arfken & H. Weber.
2. Mathematical Methods in the Physical Sciences – M. Boas.
3. Higher Engineering Mathematics – B.S. Grewal.
4. Mathematics for Physicists & Engineers – Pipes.
5. Complex Variables & Applications – R.V. Churchill.
6. The Use of Integral Transforms – I.N. Sneddon.
7. A Text Book of Mathematical Physics – S. Chandra.
8. Mathematical Physics – H.K. Dass & R. Verma.
9. Mathematical Physics – P.K. Chattopadhyay.

Thermal Physics

Course Objectives:

1. Overview of various thermodynamic functions, relation among them, and variation with pressure, volume, &temperature.
2. Acquaint students with concept of
    - i. Thermodynamic systems – closed, open, & isolated.
    - ii. Intensive & extensive properties.
    - iii. First, second, & third laws of thermodynamics.
    - iv. Reversible and irreversible processes.
    - v. State function, entropy, work done *by* and *on* the system.
    - vi. Adiabatic process, isothermal process.
    - vii. Carnot's engine/cycle.
    - viii. Efficiency of engine.
    - ix. Specific heat at constant pressure & volume.
    - x. Maxwell's relations.
    - xi. Thermodynamic functions, relation among them.
    - xii. Critical constants – critical temperature, critical volume, critical pressure.
    - xiii. Real gas, various equations of state, Van der Waals equation of state.
    - xiv. Joule-Thomson effect & Joule-Thomson cooling.

Learning Outcomes: After completion of the course the learners will

1. Comprehend concepts of thermodynamics, laws of thermodynamics, concept of entropy and the associated theorems, PV diagram, thermodynamic potentials and their physical interpretations.
2. Be able to
    i. Answer/solve questions/problems related to
        a) Heat propagation through media.
        b) Work-energy, second law of thermodynamics.
        c) Specific heat of gases.
        d) Thermodynamic functions (enthalpy, Gibb's free energy, Helmholtz function).

Heat: Thermometry and calorimetry: Concept of heat and temperature, different scales of temperature and relation among them, thermometric principle, different types of thermometers (liquid, gas, resistance, thermo-couple, pyrometers), low temperature measurement, concept of Calorie, basic principle of calorimetry, thermal capacity and specific heat, specific heat of solids, liquids, and gases, C_P and C_V and relation between them, concept of equation of state, molar mass, total mass, number of moles, moles, and Avogadro's number, ideal gas equation, real gas equation, PV-diagram, molecules and intermolecular forces, concpet of kinetic theory of gases and phases of matter.

Heat transfer mechanism: Conduction, convection, and radiation, thermal conductivity, temperature gradient, brief discussion on methods of conductivities of solids, liquids, & gases, cylindrical heat flow method for glass or rubber tube, Wiedemann-Franz's law (ratio of thermal to electrical conductivity) conduction through composite slab, expansion of solid (linear, surface, and volume, & relation among them), expansion of liquid, latent heat, Newton's law of cooling, properties of radiation, brief account of blackbody radiation, concept of absorptive, reflective, & emissive powers of a surface, radiation and climate change.

Thermodynamics: Zeroth and first law of thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law, General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

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 & efficiency, refrigerator & coefficient of performance, Kelvin-Planck and Clausius statements and their equivalence, Carnot's theorem, applications (thermodynamic scale of temperature and its equivalence to perfect gas scale).

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, entropy changes in reversible and irreversible processes, principle of increase of entropy, temperature–entropy diagrams for Carnot's Cycle, third law of thermodynamics, unattainability of absolute zero.

Thermodynamic potentials: Thermodynamic Potentials: Internal energy, Definitions, properties and applications of Enthalpy, Helmholtz Free Energy, Gibb's free energy, concept of phase, first and second order phase transitions with examples, Clausius-Clapeyron and Ehrenfest equations.

Maxwell's thermodynamic relations: Derivations and applications of Maxwell's relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) values of C_p-C_v, (3) TdS equations, (4) Joule-Kelvin coefficient for ideal and Van der Waal gases, (5) energy equations, (6) change of temperature during adiabatic process.

Real Gases: Behavior of real gases, deviations from the ideal gas equation, the virial equation, Andrew's experiments on co_2 gas, 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, law of corresponding states, comparison with experimental curves, P-V diagrams, Joule's experiment, free adiabatic expansion of a perfect gas, Joule-Thomson porous plug experiment, Joule-Thomson effect for real and Van der Waal gases, temperature of inversion, Joule-Thomson cooling.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Heat and Thermodynamics – M.W. Zemansky & Richard Dittman, McGraw-Hill.
2. A Treatise on Heat – Meghnad Saha & B.N. Srivastava, 1958, Indian Press.
3. Thermal Physics – S. Garg, R. Bansal, & Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
4. Modern Thermodynamics with Statistical Mechanics - Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics - Sears & Salinger, Narosa.
6. Concepts in Thermal Physics – S.J. Blundell & K.M. Blundell, Oxford University Press.
7. Thermal Physics – A, Kumar & S.P. Taneja, R, Chand Publications.
8. Sears & Zemansky's University Physics with Modern Physics – H.D. Young, R.A. Freedman, & A.L. Ford, Pearson.
9. Fundamentals of Physics – D. Halliday, R. Resnick, & J. Walker.
10. University Physics – H. Bension, John Wiley & Sons.
11. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett, Thomson.
12. Essential University Physics – R. Wolfson, Addison-Wesley.
13. Understanding Physics – M. Mansfield & C. O'Sulliban, Wiley.
14. Physics for Scientists & Engineers with Modern Physics – Giancoli.
15. Thermal Physics – C. Kittel & H. Kroemer, McMillan Education India.
16. Thermal & Statistical Physics – M. Das, P.K. Jena, & R.N. Mishra.

Analog Systems and Applications

Course Objectives:

1. Acquaint students with the basic concept of

i. P and N type semiconductors and application of F-D statics in relation to the various properties of semiconductor.
ii. Diodes and their applications such as rectifiers, filters, regulators, etc.
iii. Working principle of BJT and FET; negative and positive feedback.
iv. Applications of BJT & FET as rectIfiers, regulators, amplifiers etc.
v. Working principles and applications of
    a) Operational amplifiers (OP-AMP).
    b) Various oscillators such as phase shift, Wien Bridge oscillators, crystal oscillators, tunnel-diode oscillator, & relaxation oscillator.
    c) Modulators - amplitude, power, & frequency modulation, analysis of AM wave, modulator, demodulator circuits.
    d) Active, passive, low pass, high pass, and band reject filters.
    e) Astable monostable multivibrators

2. To develop theoretical skills to understand and design electronic circuits & devices.
3. To train to handle electronic components, devices.
4. To build necessary competency to trouble-shoot electronic devices.
5. To design and perform basic and applied research involving extensive electronic circuitry.

Learning Outcomes: After completion of the course, students are expected to

1. Assimilate and possesses basic knowledge of following
    i. N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions.
    ii. Applications of F-D statics to semiconductors.
    iii. To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells.
    iv. Application of PN junction for different type of rectifiers and voltage regulators.
    v. NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
    vi. FET and BJT amplifiers and their working principles.
    vii. Operational amplifiers and knowledge about different configurations namely inverting and non-inverting and applications of operational amplifiers
    viii. Demonstrate inverting and non-inverting amplifiers using op-amps.
    ix. Various types of oscillators and their working principles.
    x. Amplitude modulation, frequency modulation, power modulation and their various applications in communication technology.
    xi. Working principles and applications of active & passive filters, low pass, high pass, and band reject filters.
2. Answer basic and conceptual questions and solve basic problems related to diodes, transistors, amplifiers, oscillators, modulation, filters, & multivibrators.
3. Handle various sophisticated electronic devices.
4. Understand the circuit diagrams of basic and high-end electronic instruments involving various electronic components.
5. Design simple and low-cost as well as complex electronic circuits/devices by choosing appropriate components.
6. Pursue higher studies in electronics.
7. Get involved quickly in advanced laboratories.

8. Design and conduct experiments for basic and applied research involving extensive electronic circuitry.
9. Apply the concepts of electronics in communication.

Semiconductors: Introduction, intrinsic & extrinsic semiconductors, conduction & valence band, energy band/band gap, doping, p- & n- type, F-D statistics, Fermi level, Fermi energy, & Fermi velocity, electrons & holes and their mobility, concentration, dependence of concentration on temperature, Hall effect.

Diode Circuits: Current-Voltage characteristics, ideal rectifier, junction diode, rectifier circuits – half-wave, full-wave, & bridge rectifier, voltage doubler, filter circuits (capacitor, L-section, & π-section filters), diode regulators (Zener diodes & controlled rectifiers), diode circuits (clippers, clamps, LED, & photodiode).

Transistors: Bipolar junction transistor (BJT), pnp & npn transistors, characteristics, different configurations (CC, CE, & CB) & comparison, characteristics of MOSFET.

Amplifiers: Field Effect Transistor (FET) amplifiers (operating point, small-signal parameters, source follower), Bipolar Junction Transistor (BJT) amplifiers (bias circuit, hybrid parameters), Operational Amplifier (OP AMP) (circuit symbol, characteristics & some applications), voltage & power amplifiers (classification, R-C coupled transistor amplifier, power amplifiers, class A & B, comparators, Schmidt trigger), feedback (block diagram & negative feedback).

Oscillators: Positive feedback, RC oscillators (phase shift, & Wien Bridge oscillators), resonant-circuit oscillators (LC & crystal oscillators), negative resistance oscillator (stability analysis & tunnel-diode oscillator), relaxation oscillator (swatooth generators & multivibrators), waveform generators (diode pump, ramp, & pulses).

Modulation & demodulation: Introduction, amplitude, power, & frequency modulation, analysis of AM wave, modulator, demodulator circuits.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Basic Electronics for Scientists and Engineers – D.L. Eggleston.
2. Electronics Principle and Applications – D. Chattopadhyay & P.C. Rakshit.
3. The Art of Electronics – P. Horowitz & W. Hill.
4. Analog Electronics for Scientists – D. Barnaal.
5. Basic Electronics for Scientists – J.J. Brophy.
6. An Introduction to Modern Electronics – W.L. Faissler & J.C. Sprott.
7. Introduction to Electronics – E.D. Gates.
8. Fundamentals of Electric Circuits – C.K. Alexander & M.N.O. Sadiku.
9. Introductory Electronics for Scientists & Engineers – R.E. Simpson, Allyn, & Bacon.
10. Electronic Principles – A. Malvino.
11. Digital Principles & Applications – D. Leach & A. Malvino.

12. Principles of Communication Systems – Taub and Achilling.
13. Foundations of Electronics – D. Chattopadhyay, P.C. Rakshit, B. Saha, & N.N. Purkait.
14. Electronics for Scientists & Engineers – T.R. Vishwanathan, G.K. Mehta, & V. Rajaraman.
15. Principles of Electronics – V.K. Mehta.
16. Handbook of Electronics – Gupta and Kumar.

Physics Lab. – III

Course Objectives:
1. Verify physical laws through experiments.
2. Verify concept and applications of semiconductor physics and p-n junction diodes.
3. Provide knowledge of various electronic devices/components.
4. Will have clear understanding of various electronic devices/components - transistors, operation amplifiers, modulators.
5. Impart necessary technical skills to understand, handle, design, & trouble-shoot electronic devices.

Learning Outcomes: After completion of the course the learners will
1. Have
   iii. Better understanding of the underlying principles of various physical phenomena.
   iv. Knowledge of various hardware and software components.
   v. In depth knowledge of heat and thermodynamics.
   vi. Concept of working principles of electronic devices.
2. Be able to
   iii. Handle various equipments.
   iv. Analyze data using Origin software.
   v. Able to design electronic circuits.
   vi. Understand/analyze critical electronic circuits.
   vii. Trouble-shoot electronics & other devices.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

1. Experiment with ideal and real gases.
2. Coefficient of thermal conductivity of Cu.
3. Coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method.
4. Temperature coefficient of resistance by Platinum Resistance thermometer.
5. Mechanical equivalent of heat.
6. Heat engines.
7. Calorimeter – compare electrical energy input to changes in internal energy.
8. Thermocouple.
9. Absolute zero temperature.
10. Stefan-Boltzmann law.
11. p-n junction diode & band gap.
12. Characteristics of BJT & FET transistors.
13. Amplifiers – operational and feedback amplifiers.

14. Oscillators.
15. Multivibrators.
16. Filters.
17. Characteristics of LED, Solar cell, UJT, and Zener diode.
18. Modulation.
19. Experiments with IC.

Skill Enhancement Course (SEC) -1

Computational Physics

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.
(i) Highlights the use of computational methods to solve physical problems
(ii) Use of computer language as a tool in solving physics problems (applications)
(iii) Course will consist of hands on training on the Problem solving on Computers.

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Rootsof Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. UGC Document on LOCF Physics 207 Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

Control Statements: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:
1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1 `

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions),
Understanding data with Gnuplot

Hands on exercises:
1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot. Plotting trajectory of a projectile projected horizontally.
6. Plotting trajectory of a projectile projected making an angle with the horizontally.
7. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen.
8. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).
3. LaTeX–A Document Preparation System”, Leslie Lamport (Second Edition, Addison Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)

5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3 r d E d n . , 2 0 0 7 , Wiley India Edition

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Semester – IV

Mathematical Physics - III

Course Objectives: Impart knowledge of
1. Complex functions and variables.
2. Various series (Infinite, Taylor's, and Laurent's Series).
3. Complex differentiation.
4. Cauchy-Riemann equation & L'Hospital's rule.
5. Jordan's and Green's theorem.
6. Residue theorem.
7. Laplace transform and its various applications.
8. Various special functions.

Learning Outcomes: After completion of the course, learners will be able to
1. Solve various complex series (Infinite, Taylor's, and Laurent's Series).
2. Solve complex integration using Residue theorem.
3. Apply the concept of complex variables/functions in other branches of physics (solid state physics, materials science).
4. Apply the concept of Laplace transform and special functions in various branches of physics.

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: Laplace Transforms: Laplace Transform (LT) of elementary functions, change of scale theorem, shifting theorem, 1^{st} and 2^{nd} order derivatives and integrals of functions, derivatives and integrals, unit step function, Dirac delta function, periodic functions, convolution theorem, inverse LT, various applications such as damped harmonic oscillator, simple electrical circuits, coupled differential equations of 1^{st} order, solution of heat flow along infinite bar etc.

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 functions, properties and differential equations, generating function, recurrence relation, orthogonality.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Mathematical Methods for Physicists – G. Arfken & H. Weber.
2. Mathematical Methods in the Physical Sciences – M. Boas.
3. Complex Variable – M.R. Spiegel (Schaum series).
4. Higher Engineering Mathematics – B.S. Grewal.
5. Mathematics for Physicists & Engineers – Pipes.
6. Complex Variables & Applications – R.V. Churchill.
7. The Use of Integral Transforms – I.N. Sneddon.
8. A Text Book of Mathematical Physics – S. Chandra.
9. Mathematical Physics – H.K. Dass & R. Verma.
10. Mathematical Physics – P.K. Chattopadhyay.

Elements of Modern Physics

Course Objectives: To impart knowledge of

1. Special theory of relativity - Einstein's postulates, Lorentz Transformation and its applications (time dilation, length contraction, proper length and proper time, simultaneity, & twin paradox).
2. Relativistic dynamics.
3. Relation between relativity and electromagnetism.
4. Minkowski's four-dimensional space-time world & four-vectors.
5. Application of special theory of relativity.
6. Limitations of special theory of relativity.
7. General theory of relativity.
8. Properties of a nucleus.
9. Nuclear models.
10. Radioactivity – alpha, beta, and gamma ray.
11. Nuclear detectors and accelerators.
12. Cosmic rays and elementary particles.

Learning Outcomes: After completion of the course, learners will

1. Have basic knowledge of special theory of relativity & nuclear physics.
2. Be able to
    i. Answer basic and conceptual questions related to relativity and nuclear physics.
    ii. Solve problems related to relativity and nuclear physics.
    iii. Connect special theory of relativity and electrodynamics.
    iv. Pursue higher studies in nuclear physics and mathematical physics.

Special Theory of Relativity: Experimental Background: Galilean transformation, Newtonian relativity, electromagnetism and Newtonian relativity, Michelson-Morley experiment, concept of ether, Einstein's postulates of special theory of relativity.

Lorentz Transformation: Lorentz transformation, time dilation, length contraction, proper length and proper time, simultaneity, twin paradox.

Relativistic Dynamics: Relativistic mass, momentum, force, acceleration, equivalence of mass and energy ($E = mc^2$), collision, mass defect and binding energy, transformation properties of mass, momentum, energy, force, and acceleration, invariance of space-time and energy-momentum under Lorentz transformation.

Minkowsky space: Linear orthogonal transformation & its invariants, Minkowski's four-dimensional space-time world, Lorentz transformation as rotation in four-space, four-vectors, tensor algebra, anti-symmetric four-tensor, group property of Lorentz transformation.

Optical applications of Lorentz transformation: Elements of wave propagation, frequency & wave-vector transformations, relativistic Doppler effect, aberration, reflection of light by a moving mirror, propagation of light in a moving medium, Fresnel's dragging coefficient.

Relativity and electromagnetism: The interdependence of electric and magnetic fields, transformations for **E** and **B,** force and field near a current carrying wire, force between moving charges.

Applications and possible limitation: Brief account of experimental verification of special theory of relativity, Thomas precession, spin-orbit interactions, relativistic classification of particles, zero rest mass (photons and neutrinos), de Broglie waves for a free particle, uncertainty relation, qualitative discussion on the possible limitations of special theory of relativity.

Nuclear Physics: Atomic Nucleus: Structure of nucleus (Thomson model, Rutherford model, protron-electron model, proton-neutron hypothesis), properties of nucleus [mass, radius, density, nuclear angular momentum, magnetic moment, electric quadrupole moment, wave mechanical properties – BE and FD statistics, parity, atomic mass, nuclear stability, nuclear forces (Meson theory), isotopes, isotones, isobars, isomers, and mirror nuclei].

Nuclear model: Liquid drop model, semi empirical mass formula (Weizacker's semi-empirical formula), Shell model, magic number nuclei.

Radioactivity: Radioactive nucleus, artificial radioactivity, radioactive disintegration, average life time and radioactive constant, half-life and mean-life period, carbon dating, α-, β-, and γ- decay, Rutherford theory of scattering of α-particles.

Nuclear reactions: $E = mc^2$, mass defect, binding energy and *Q* value, transmutation, nuclear energy, nuclear fission, nuclear reactors, types of nuclear reactors, Breeder reactors, nuclear fusion, nuclear fusion in stars, nuclear fusion reactors.

Interaction of nuclear radiation with matter: Brief discussion about various types of neutron (thermal, slow, fast), rate of energy loss, Bethe-Bloch formula, absorption of γ-rays in matter, linear and mass absorption coefficient, annihilation of electron-positron pair, Dirac's theory of pair production, Compton effect.

Detectors for nuclear particles: Interaction between particles and matter, ionization counter, Geiger-Muller counter, scintillation counter, solid state or semiconductor detectors, Compton suppressed germanium detectors, Cloud and Bubble chambers, Spark chamber.

Brief introductions of particle accelerators: Van de Graff Generator, Linear Accelerator, Cyclotron, Pelletron, Synchrotron, Betatron, idea of large hadron collider (LHC).

Cosmic rays and elementary particles: Introduction, primary and secondary cosmic rays, altitude, latitude, & East-West effect, cosmic ray shower, classification of elementary particles (gravitons, photons, leptons, hadrons etc,), quarks, antiparticle.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Special theory of Relativity – R. Resnick.
2. Special Theory of Relativity – S.P. Puri.
3. A First Course on General Relativity – B. Schutz.
4. Nuclear & Particle Physics: An Introduction – B.R. Martin.
5. Nuclear & Particle Physics – W.E. Burcham & M. Jobes.
6. Introductory Nuclear Physics – K.S. Krane.
7. Introductory Nuclear Physics – S.S.M. Wong.
8. Nuclear Physics – V. Devnathan.
9. Concepts of Nuclear Physics – B.L. Cohen.
10. Fundamentals of Nuclear Physics – B.B. Srivastava.
11. Introduction to Nuclear Physics – H.S. Enge.
12. Nuclear Structure – M.K. Pal.
13. Atomic & Nuclear Physics – Vol. II – S.N. Ghoshal.
14. Particle Physics: A Very Short Introduction – F. Close.

Digital Systems and Applications

Course Objectives: Objectives of Digital Electronics course are

1. To acquaint students with concepts of
   - i. Digital number systems & codes.
   - ii. Boolean functions.
   - iii. Sum of product (SOP) and product of sum (POS) representations & Karnaugh maps.
   - iv. Various gates – AND, NOR, OX, NOR, NAND.
   - v. NAND and NOR as universal gates.
   - vi. J-K, S-R, clocked, master-slave, & edge-triggered flip-flops.

vii. Display and memory systems.
viii. Introduction to A/D conversion, Digital-to-analog (DAC) & analog-to-digital (ADC) convertion.
ix. A/D data-acquisition system.
x. Multiplexers & demultiplexers.
xi. 4-Bit, 8-Bit, 16-Bit, & 32-Bit systems.
xii. Microprocessor.
xiii. General Purpose Interface Bus (GPIB), GPIB signals and lines, implementation of a GPIB on a PC.
xiv. Digital pulse modulation .

2. To develop theoretical knowledge and know-how to understand and design electronic circuits & devices.

Learning Outcomes: This course will enable students to

1. Have understanding of
   i. The basics of IC and digital circuits, and difference between analog and digital circuits.
   ii. Various logic GATES and their realization using diodes and transmitters.
   iii. Fundamental of Bolean algebra and their role in constructing digital circuits.
   iv. About combinatorial and sequential systems by building block circuits to construct multivibrators and counters.
   v. Sequential systems by choosing Flip-Flop as a building bock.
   vi. Memory (RAM & ROM) and memory organization.
   vii. Microprocessor and assembly language programming with examples with special reference to IntelµP 8085.
   viii. Modulation and demodulation of digital & analog signals and optical communication.
2. Solve problems related to Boolean algebra, logic gates, flip-flops.
3. Apply the concept of digital electronics in
   i. DAC/ADC and DAQ/PC interface.
   ii. Digital communications and data transmission.
4. Handle high-end electronic components/systems.
5. Set-up complex Physics (e.g., optics, atomic, molecular, and nuclear) experiments requiring high-end and expensive electronic components/devices.
6. Design digital circuits for research in applied physics & technology.
7. Trouble-shoot complicated experimental set-up.

Integrated Circuits: Active & passive components, discrete components, wafer, chip, advantages and drawbacks of ICs, scale of integration (SSI, MSI, LSI and VLSI) (basic idea and definitions only), classification of ICs, examples of linear and digital ICs.

Number systems: Positional number system, binary representation, 2’s complement notation, binary addition and subtraction, octal number system, hexadecimal system, binary codes (BCD and ASCII codes).

Boolean algebra: Switching circuits, AND, OR and NOT operations, truth table, Boolean functions, postulates and theorems of Boolean algebra, duality principle, Venn diagram, canonical forms of

Boolean functions, simplification of Boolean functions, sum of product (SOP) and product of sum (POS) representations, Karnaugh maps, incompletely specified functions, don't cares.

Combinational and sequential circuits: Logic gates, NAND and NOR as universal gates, realization of logical functions using SOP and POS techniques, XOR gate, decoders, encoders, multiplexers, de-multiplexers, code conversion using logic gates and MSI ICs, half adder, full adder, serial adder, half subtractor, full subtractor, digital comparator, TTL & CMOS.

Linear and Non-Linear Wave Shaping : High pass RC circuits and their response for sinusoidal, step, pulse, square, & ramp inputs, high pass RC network as differentiator, low pass rc circuit as an integrator, attenuators and its application as a CRO probe.
diode clippers, clipping at two independent levels, comparators, applications of voltage comparators. clamping operation, clamping circuit taking source and diode resistances into account, clamping circuit theorem, practical clamping circuits, effect of diode characteristics on clamping voltage, synchronized clamping.

Information registers: Flip-flops (J-K, S-R, clocked, master-slave, & edge-triggered flip-flops), synchronizer, timer, counter, shift register.

Memory circuits: Read only memories, shift-register memories, Random-Access Memories.

Microprocessor Architecture: Introduction, 4-Bit, 8-Bit, 16-Bit, & 32-Bit systems, components, brief description of 8085/8086 microprocessor.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.
Scope of the syllabus is defined from following recommended books:

1. Basic Electronics for Scientists and Engineers – D.L. Eggleston.
2. Electronics Principle and Applications – D. Chattopadhyay & P.C. Rakshit.
3. The Art of Electronics – P. Horowitz & W. Hill.
4. Analog Electronics for Scientists – D. Barnaal.
5. Basic Electronics for Scientists – J.J. Brophy.
6. An Introduction to Modern Electronics – W.L. Faissler & J.C. Sprott.
7. Introduction to Electronics – E.D. Gates.
8. Fundamentals of Electric Circuits – C.K. Alexander & M.N.O. Sadiku.
9. Introductory Electronics for Scientists & Engineers – R.E. Simpson. Allyn. & Bacon.
10. Electronic Principles – Malvino.
11. Digital Principles and Applications – Malvino and Leech.
12. Principles of Communication Systems – Taub and Achilling.
13. Foundations of Electronics – D. Chattopadhyay. P.C. Rakshit. B. Saha, & N.N. Purkait.
14. Electronics for Scientists & Engineers – T.R. Vishwanathan. G.K. Mehta, & V. Rajaraman.
15. Principles of Electronics – V.K. Mehta.
16. Handbook of Electronics – Gupta and Kumar.
17. Digital Electronics and Logic Design – S.K. Mandal.
18. PC Based Instrumentation: Concepts & Practice – N. Mathiavanan.
19. Microprocessor Architecture Programming & Applications – R.S. Gaonkar.

20. Microprocessor 8085: Architecture. Programming. & Interfacing – A. Wadhwa.
21. Learning with LabVIEW – R.H. Bishop.
22. Data Acquisition Using LabVIEW – B. Ehsani.
23. LabVIEW for Everyone: Graphical Programming Made Even Easier – L.K. Wells & J. Travis.

Physics Lab. - IV

Course Objectives:
1. Verify concept of modern physics through experiments.
2. Provide hands-on training on various equipments.
3. Develop programing skills using software/programing language.

Learning Outcomes: After completion of the course learners will be able to
1. Analyze experimental results/data using Origin software.
2. Set-up physics/applied physics experiment.
3. Handle sophisticated instrument.
4. To design and perform basic and applied research involving extensive electronic circuitry.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

[NOTE: Necessary permission/clearance is required from Atomic Energy Regulatory Board (AERB), GoI, (https://aerb.gov.in/index.php/english/elora) for Nuclear Physics Experiments**]**

[NOTE: Lectures on **Digital Data Communication Standards** should be given in the lab.

Syllabus: Digital Data Communication Standards: Serial communications: RS232. handshaking. implementation of RS232 on PC; Universal Serial Bus (USB) – USB standards. types and elements of USB transfers.

Parallel communications: General purpose interface bus (GPIB). GPIB signals and lines. handshaking and interface management. implementation of a GPIB on a PC; basic idea of sending data through a COM port.]

1. Experiments with Alpha. Beta. & Gamma rays and GM Counter.
2. Planck’s constant using blackbody radiation and photo-detector.
3. Work function of a material of filament of directly heated vacuum diode.
4. Planck’s constant using LEDs of at least 4 different colors.
5. Experiments decided by lab. instructor.
6. Experiments with IC, ADC, DAC, timer, TTL, coder, decoder, & multiplexer.
7. To verify truth table of (i) NOT, OR, NOR, AND, NAND, XOR, & NXOR gates with 3 and 4 inputs.
8. To study functioning of NAND gate as universal gate.
9. To design the circuit of (i) Half Adder, Full Adder, Half Subtractor, Full Subtractor.
10. To study (i) R-S Flip-flop, D Flip-flop, & J-K Flip-flop.

11. Experiments with NI module, microprocessors, and microcontrollers.
12. LabVIEW programming, interfacing and DAQ with stand-alone instruments such as DSO and WFG and concept of PCB.
13. Bus signals & interfacing – fundamental bus signals – data address, strobe; programmed I/O – data in, programmed I/O, status registers, interrupt, direct memory access, serial communication and ASCII, GPIB, RS 232.
14. PCB design.
15. Experiments decided by lab. Instructor.

Skill Enhancement Course (SEC) - 2

Instrumentation

Course Objectives:

1. Provide knowledge of various physics instruments and experimental set-ups.
2. Verify concept and applications of various physical phenomena.
3. Provide knowledge of advanced instruments/software.
4. Impart necessary technical skills to understand, handle, design, & trouble-shoot a devices.

Learning Outcomes: After completion of the course the learners will

1. Have
    i. Better understanding of the underlying principles of various physical phenomena.
    ii. Knowledge of various hardware and software components.
    iii. In depth knowledge of analog electronics.
2. Be able to
    i. Handle various equipments.
    ii. Analyze data using Origin software.
    iii. Able to design electronic circuits & set-up experiments.
    iv. Understand/analyze critical electronic circuits and various physics related instruments.
    v. Trouble-shoot electronics & other devices.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

1. Beam profile of a He-Ne laser.
2. Experiment with microwaves and ultrasonic waves.
3. Interferometer.
4. Thermal and electrical conductivity of solids.
5. Experiments with transducers & sensors.
6. Introduction of LabVIEW & digital electronics lab. with LabVIEW.
7. Experiments with flip-flops, counters, timers, multiplexer/demultiplexer, and registers.
8. Basic programming exercises on 8085/8086 Microprocessor.
9. Measurement of voltage, frequency, time period and phase angle using CRO
10. Signal Generators and Analysis Instruments.

11. Experiments with waves, optics, and electricity & magnetism.
12. Beats.
13. Doppler effect.
14. Forced oscillation & resonance.
15. Experiments with IC.
16. Experiment decided by Lab. instructor.

Suggested books:

1. PC Based Instrumentation: Concepts & Practice – N. Mathiavanan.
2. Microprocessor Architecture Programming & Applications – R.S. Gaonkar.
3. Microprocessor 8085: Architecture, Programming, & Interfacing – A. Wadhwa.
4. Learning with LabVIEW – R.H. Bishop.
5. Data Acquisition Using LabVIEW – B. Ehsani.
6. LabVIEW for Everyone: Graphical Programming Made Even Easier – L.K. Wells & J. Travis.

Semester – V

Quantum Mechanics and Applications

Course Objectives: Acquaint students with

1. Foundation of quantum mechanics – failure of classical mechanics, blackbody radiation, wave-particle duality, de-Broglie hypothesis, experiments with electrons, γ-ray microscope experiment, phase & group velocity, uncertainty principle.
2. Concept of operator formalism - position, momentum and energy operators, operator algebra, commutator, Hermitian operators, eigenfunctions & eigenvalues, Vector space, Hilbert space, bra & ket algebra, Dirac delta function, Kronecker delta function, Schrödinger and Heisenberg pictures.
3. Schrodinger equation and its applications (e.g., particle in one- & three-dimensional potential box, quantum mechanical tunneling, potential barrier, delta potential, potential step, transmission coefficient, Hydrogen atom, quantum numbers – *n, l, m, s*).
4. Concept of identical particles.

Learning Outcomes: After completion of the course, learners will

1. Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
2. Understand the theory of quantum measurements, wave packets and uncertainty principle.
3. Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques.
4. Be able to
    i. Construct Schrodinger equation in Cartesian and Spherical coordinates.
    ii. Answer questions and solve problems related to

a) Uncertainty principle, blackbody radiation, Group & phase velocity, de-Broglie wavelength and apply in x-ray diffraction technique.
b) Solve Schrodinger equation in one and three dimension under different boundary conditions.
c) Potential barrier, *e.g*., tunneling through potential barrier, step potential, rectangular barrier.
d) Quantum mechanical operators and Heisenberg uncertainty principle, Hydrogen atom.

iii. Apply the concept of quantum mechanics in other brnaches of science (atomic, molecular, nuclear, & solid state physics physics/chemistry, statistical mechanics, nano-science, materials science)

Introduction: Blackbody radiation, Planck's quantum hypothesis, Photoelectric effect, Compton effect, specific heat of solids, de Broglie wavelength/wave-particle duality, Davison-Germer experiment, wave packets/Gaussian wave packet, phase and group velocity, concept of wavefunction, differences between classical & quantum mechanics, Heisenberg's uncertainty principle, Fourier transform and momentum-space wavefunction (i.e. expansion of a wave function in terms of position and momentum wavefuntions).

Operator Formalism and Schrödinger Equation: Operator formalism, position, momentum and energy operators, operator algebra, commutator, expectation value, Ehrenfest theorem, Hermitian operators, Hermitian adjoint, various properties of Hermitian operator, operators commuting with H, simultaneous eigen functions of commuting operators, postulates of quantum mechanics, Schrodinger equation, free particle solution, superposition of wavefunctions, stationary states, orthogonality of eigenfuntions, degenerate & nondegenrate eigenvalues, probability current density, time dependent and time independent Schrödinger equation.

Applications of Schrodinger equation in simple cases: One dimension-infinite square well potential, both one and three dimensional cases of a particle in a box, finite square well, attractive delta function potential, harmonic oscillator, potential step, and potential barrier, simple harmonic oscillator.

Bra and Ket Algebra: Vector space, Hilbert space, wave function as a vector, Dirac's notation, basis vector, expectation value, Dirac delta function and Kronecker delta function, linear operator, eigenvalue equation, observables, completeness condition, relationship between ket and wavefunction, statistical interpretation, linear harmonic oscillator, uncertainty relation, coherent states, simultaneous eigenkets of commuting operators, unitary transformation, Schrödinger and Heisenberg pictures and interaction between them, density operator.
Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Quantum Mechanics – R. Shankar.
2. Quantum Mechanics – B.H. Bransden & C.J. Joachin.
3. Introduction to Quantum Mechanics – D.J. Griffith.
4. Quantum Mechanics – Ghatak & Loknathan.

5. Quantum Mechanics – L.I Schiff.
6. Modern Quantum Mechanics – J.J. Sakurai.
7. Quantum Mechanics (Vol. II) – C. Cohen-Tannoudji. B. Die. & F. Laloë.
8. Quantum Mechanics – A. Das.
9. Quantum Mechanics – S. Gasiorowicz.
10. Introductory Quantum Mechanics – R.L. Liboff.
11. Quantum Mechanics 500 Problems & Solutions – G. Aruldhas.
12. Quantum Mechanics – Y. Peleg. R. Pnini. E. Zaarur. & E. Hecht (Schaum series).
13. Sears & Zemansky's University Physics with Modern Physics – H.D. Young. R.A. Freedman. & A.L. Ford. Pearson.
14. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett. Thomson.
15. Physics for Scientists & Engineers with Modern Physics – Giancoli.
16. Conceptual Physics – P.G. Hewitt. Pearson.
17. Physics for Scientists & Engineers with Modern Physics – P.M. Fisbane. S.G. Gasiorowicz. & S.T. Thornton. Pearson.
18. Modern Physics – P. Tipler.

Solid State Physics

Course Objectives:

1. Acquaint students with
    i. Various types of
        a) Crystal structures.
        b) Projections – spherical, zenithal, polar, and meridian.
    ii. Symmetry of crystals.
    iii. Symmetry elements and their notations of crystals.
    iv. Concept X-ray diffraction (Bragg law, Fourier analysis, Laue equation) and construction of Brillouin zone from the diffraction pattern.
    v. Miller indices and its applications in various crystal structures.
    vi. Energy bands in solids, classification of solids.
    vii. Application of F-D statistics in solids.
    viii. Various properties of solids - thermal, electrical, & optical properties.

2. Provide
    i. Overview of various type of various space groups and their nomenclatures of crystals.
    ii. Knowledge about reciprocal lattice and Brillouin and their relation applications in different structures (e.g., cubic, face centered, body centered etc.).

Learning Outcomes: After completion of the course, learners will be able to

1. Classify the crystals (*i.e.*, face centered, body centered, face centered).
2. Determine lattice parameters/constant (a, b, and c-axes) of simple crystals.
3. Construct various projections associated with crystal structures.
4. Apply the concept of symmetry to determine structure of a crystal and classify the crystal.

5. Transform the crystals axes.
6. Determine Miller indices of a given crystal.
7. Construct reciprocal lattice vectors and Brillouin zone of a given crystal and correlate them.
8. Analyze the X-ray diffraction pattern of crystals.

Crystal structure: Various types of bonding, Lennard Jones potential, periodic array of atoms – lattice translation vectors, basis & crystal structure, primitive lattice cell, different types of lattice, Miller indices, simple crystal structures – sodium chloride & cesium chloride structures, hcp, diamond structure, cubic zinc sulphide structure etc,, nonideal crystal structures – random stacking and polytypism, Miller indices, reciprocal lattice vectors, reciprocal lattice unit cells, reciprocal lattice cells for cubic crystals, proofs of some geometrical relationships using reciprocal lattice vectors, Brillouin zones – reciprocal lattice to sc, bcc, & fcc lattices, X-ray diffraction, Bragg's law, atomic & geometrical factor.

Energy band: Free electron theory of metals - thermal & electrical conductivity, Drude-Lorentz theory, Somerfield's theory, Lorentz number, merits & demerits of free electron theory, F-D statistics, Fermi energy, Fermi level, Fermi velocity, density of states, band theory of solids, classification of solids (metals, semiconductor, & insulators) on the basis of band theory, Brillouin zone and origin of band gap, Kronig-Penny model, effective mass of electron, direct & indirect band gap semiconductors.

Semiconductors: Introduction, intrinsic & extrinsic semiconductors, conduction & valence band, energy band/band gap, doping, p- & n- type, F-D statistics, Fermi level, Fermi energy, & Fermi velocity, electrons & holes and their mobility, concentration, dependence of concentration on temperature, Hall effect.

Properties of solids: Thermal properties: Lattice vibration, vibration of 1-D monoatomic & diatomic lattice, concept of phonon, phonon dispersion relation, specific heat of solids, Widemann-Franz law, Dulong-Petit law, Einstein & Debye's theory, density of states.

Dielectric properties: Polarization, dielectric constant, polarizability, local electric field, Clausius-Mossotti relation (derivation), electronic, ionic, & dipolar polarizability, ferroelectricity, piezoelectricity,

Magnetic properties: Magnetic dipoles, atomic magnetic moment, magnetic susceptibility, concept of diamagnetism, paramagnetic, ferromagnetism, & magnetic domain, magnetization (**M**), field of a magnetized object, bound currents, Ampere's law in magnetic materials, concept of magnetic intensity (**H**), susceptibility, Bohr magnetron, relation between **B**, **M**, and **H,** magnetic hysteresis & **B**-**H** curve, boundary conditions on **B** and **H,** Maxwell's equations, Ampere's law with Maxwell's correction.

Optical properties: Brief qualitative discussion of optical properties, complex refractive index, extinction coefficient.

Defects in Solids: Introduction. brief account of various types of defects.

Superconductivity: Introduction, transition temperature, critical magnetic field, Meissner effect, type-I & type-II superconductors, qualitative analysis of BCS theory.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Introduction to Solid State Physics – C. Kittel.
2. Solid State Physics – A. J. Dekker.
3. Solid State Physics – N. David & N.W. Ashcroft.
4. Elementary Solid State Physics: Principles and Applications – M.A. Omar.
5. Band Theory and Electronic Properties of Solids – J. Singleton.
6. Optical Properties of Solids – A.M. Fox.
7. Magnetism in Condensed Matter – S.J. Blundell.
8. Solid State Physics – S.O. Pillai.
9. The Oxford Solid State Basics – S.H. Simon.
10. Elementary Dislocation Theory – J. Weertman & J.R. Weertman.

Physics Lab. – V

Course Objectives:
1. Verify concept of modern physics through experiments.
2. Provide hands-on training on various equipments.

Learning Outcomes: After completion of the course learners will be able to
1. Analyze experimental results/data using Origin software.
2. Set-up physics/applied physics experiment.
3. Handle sophisticated instrument.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

1. Millikan oil drop experiment.
2. Electron charge to mass ratio.
3. Photoelectric effect.
4. Hall Effect experiment.
5. Measurement of resistivity of semiconductor by four-probe method.
6. B-H curve, hysteresis loop of an iron core, and permeability.
7. Susceptibility of a paramagnetic material.
8. Dia-, para-, and ferro-magnetism in an inhomogeneous magnetic field.
9. Curie temperature measurement of ferroelectric materials.
10. Transition temperature of a high temperature superconductor and to study the Meissner effect.
11. Experiment about lattice dynamics.
12. E vs p experiment.

13. Spectra of various light sources.
14. Zeeman effect.
15. ESR & NMR.
16. Franck-Hertz experiment.

Discipline Specific Elective (DSE-1) (Physics)

Atomic and Molecular Physics

Course Objectives: Orient students with knowledge of

1. Bohr's theory of hydrogen atom.
2. Quantum theory of hydrogen atoms – Schrodinger equations and its solution.
3. Various quantum numbers – *n, l, m,* & *s*.
4. Electron spin & Pauli's exclusion principle.
5. Atomic structure and periodic table.
6. Spin – orbit coupling & total angular momentum.
7. X-ray spectra.
8. Normal and anomalous Zeeman effect, Paschen-Back effect, & Stark effect.
9. One valence and two valence electron systems.
10. Rotational spectra of diatomic molecules.
11. Vibrational spectra of diatomic molecules.
12. Electronic Spectra of Diatomic Molecules - Born - Oppenheimer approximation, molecular bonds, & Franck-Condon principle.
13. Raman, NMR, ESR, and UV-VIS-IR spectroscopy.

Learning Outcomes: After completion of the course, learner will be able to

1. Answer/solve questions/problems related rotational, vibrational, and electronic spectra of molecules.
2. Connect quantum mechanics with atomic & molecular physics.
3. Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
4. Pursue research in basic and applied physics/mathematical physics/applied mathematics.

Bohr's Theory: Rutherford experiment, Bohr's theory of hydrogen atom, de Broglie wavelength, hydrogen spectrum effect of nuclear mass, Ritz combination principle, merits & demerits of Bohr model.

Quantum Theory of Hydrogen Atom: Schrödinger equation of hydrogen atom in spherical coordinates, separation of variables, angular equation, radial equation, principle (n), orbital (l), orbital magnetic quantum (m_l) numbers, & selection rules, vector model of atom, Stern-Gerlach experiment, electron spin, Bohr magnetron, spin magnetic quantum number (m_s), total angular momentum, addition of angular momenta, spin-orbit coupling, Larmor precession; symmetric and antisymmetric wave function, LS & jj coupling, Zeeman effect, P-B effect, Stark effect.

Many Electron Atoms: Electron spin, Pauli's exclusion principle, symmetric and antisymmetric wave function, atomic structure and periodic table, spin – orbit coupling, total angular momentum, atomic spectra, characteristics X-Ray spectra.

Molecular Physics: Molecular bonds, H_2^+ molecular ion, Hydrogen molecule, types of molecules (diatomic linear, symmetric top, asymmetric top and spherical top molecules), molecule as rigid rotor and harmonic oscillator, rotational, vibrational, and electronic spectra of diatomic molecules, brief account of spectroscopy (UV-VIS-IR spectroscopy, NMR, ESR, and Raman spectroscopy), basic concept of luminescence (introduction, excitation, and emission).

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Physics of Atoms and Molecules – B.H. Bransden & C.J. Joachain.
2. Introduction to Atomic Spectra – H.E. White.
3. Introduction to Atomic Spectra – H.G. Kuhn.
4. Quantum Physics of Atoms. Molecules. Solids. Nuclei. & Particles – R. Eisberg & R. Resnick. John Wiley & Sons.
5. Atom. Laser. & Spectroscopy – S.N. Thakur & D.K. Rai.
6. Foundations of Spectroscopy – S. Duckett & B. Gilbert.
7. Fundamentals of Molecular Spectroscopy – C.N. Banwell.
8. Atomic Spectra – T.P. Softley.
9. Introduction to Molecular Spectroscopy – G.M. Barrow.
10. Introduction to Quantum Mechanics – A.C. Philips. Wiley.
11. Introduction to Quantum Theory – D. Park. Dover.

Discipline Specific Elective (DSE-2) (Physics)

<u>Semiconductor Physics and Devices</u>

Course Objectives: To develop in-depth understanding of the physics of semiconductor devices and its applications

1. Understand the importance of semiconductor materials.
2. Define a semiconductor – Conductivity, Band theory.
3. Intrinsic and extrinsic Semiconductors
4. Electronic and optical properties of semiconductors
5. Electronic Devices- FETs, TFTs, MOSFETs etc.
6. Optoelectronic devices- LEDs, Photodetectors, LASERs, solar cells etc.

Learning Outcomes: After completion of the course, learners will be able to

1. Answer/solve questions/problems related to Semiconducting materials.
2. Apply the concept of intrinsic and extrinsic Semiconductors.
3. Understanding of electronic and optical properties of semiconductors and effects of doping.
4. Understanding the physics of various electronic devices made with semiconductors.

5. Understanding the physics of various optoelectronic devices made with semiconductors.

Elemental and compound semiconductors, Energy band structures in semiconductors, dopants and defects, charge transport, electronic properties, excitons and other quasi-particles, Optical properties of semiconductors: Interband and intraband transitions, light absorption and emission.

Semiconductor junction theory, p-n junction diodes, Light emitting diode (LEDs), Photodetectors, photovoltaic, LASERS and field-effect transistors (FETs) and Thin film transistors (TFTs). The concepts of these conventional devices will be extended to the emerging areas of new generation of flexible electronic and optoelectronics devices based on unconventional materials like metal oxides and organic semiconductors.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Solid State Electronic Devices -- B.G. Streetman
2. Semiconductor Devices: Physics and Technology -- S.M. Sze
3. Semiconductors -- R. A. Smith
4. Semiconductor Physics: An introduction -- K. Seeger
5. Semiconductor Optoelectronics: Physics and Technology -- J. Singh
6. Semiconductor Optoelectronic Devices - P. Bhattacharya
7. Optoelectronics: An Introduction to Materials and Devices – J. Singh

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Semester – VI

<u>Electromagnetic Theory</u>

Course Objectives: To develop expertise in classical electrodynamics and its applications

1. Maxwell’s equation.
2. Scalar and vector potential.
3. Gauge transformation.
4. Energy, momentum, & Poynting vector/theorem of electromagnetic waves.
5. Wave equations for electric (**E**) and magnetic (**B**) fields in air and in various media (conductor & insulator).
6. Solution electromagnetic waves in media, transmission & propagation waves in various media, and guided wave.
7. Polarization of light.
8. Propagation of light through various optical media.
9. Fiber optics.

Learning Outcomes: After completion of the course, learners will be able to

6. Answer/solve questions/problems related to electromagnetic waves in air and different media.

7. Apply the concept of potential and field for transmission & propagation of electromagnetic waves.
8. Answer/solve questions/problems related to electromagnetic theory.
9. Apply various mathematical formulae for transmission & propagation of electromagnetic waves and have conceptual knowledge of radiation from point charges and dipoles.
10. Understand articles based on electromagnetic waves.
11. Understand propagation of electromagnetic waves/light through optical fibers and apply the concept in optical communication.

Maxwell Equations: Review of Maxwell's equations, displacement Current, vector and scalar potentials, Gauge transformations (Lorentz and Coulomb gauge), Boundary Conditions at Interface between Different Media, wave equations, plane waves in dielectric media, Poynting theorem and Poynting vector, Electromagnetic (EM) energy density, 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 & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction, Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law, Reflection & Transmission coefficients, Total internal reflection, evanescent waves, metallic reflection (normal Incidence).

Polarization of Electromagnetic Waves: Description of linear, circular and elliptical polarization, Propagation of EM Waves in anisotropic media, symmetric nature of dielectric tensor, Fresnel's Formula, uniaxial and biaxial crystals, light propagation in uniaxial crystal, double refraction, polarization by double refraction, Nicol prism, ordinary & extraordinary refractive indices, production & detection of plane, circularly and elliptically polarized light, quarter-wave and half-wave plates, Babinet compensator and its uses, analysis of polarized light, optical rotation, Biot's laws for rotatory polarization, Fresnel's theory of optical rotation, calculation of angle of rotation, experimental verification of Fresnel's theory, specific rotation, Laurent's half-shade polarimeter, Malus law, polaroid.

Wave Guides: Planar optical wave guides, planar dielectric wave guide, condition of continuity at interface, phase shift on total reflection, eigenvalue equations, phase and group velocity of guided waves, field energy and power transmission, brief account of Fiber optics (introduction, numerical aperture, total internal reflection, & fiber loss).

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Classical Electrodynamics – J.D. Jackson.
2. Introduction to Electrodynamics – D. Griffith.

3. Electromagnetic Theory – Bo Thidé.
4. Classical Electricity and Magnetism – W.K.H. Panofsky & M. Philips.
5. Electricity & Magnetism – A.S. Mahajan & A.A. Rangwala.

Statistical Mechanics

Course Objectives:
1. Overview of various thermodynamic functions, relation among them, and variation with pressure, volume, &temperature.
2. Acquaint students with concept
   i. of statistical mechanics – macrostate & microstate, phase and mu space, various type of ensembles.
   ii. Statistical and thermodynamic definition of entropy and relation between them.
   iii. Various statistics and distribution functions such as M-B, B-E, & F-D statistics/distributions.
   iv. Basic of kinetic theory of gases and application of M-B distribution function.
   v. Ideal Bose and Fermi systems.
   vi. Various types of ensembles in statistical mechanics.
   vii. Phase and phase transition.
   viii. Blackbody radiation and various laws - Kirchhoff's law, Stefan-Boltzmann law, Wien's law, Saha's ionization formula, Rayleigh-Jean's law, ultraviolet catastrophe.
   ix. Brownian motion and its significance.

Learning Outcomes: After completion of the course the learners will
1. Comprehend concepts of thermodynamics, laws of thermodynamics, concept of entropy and the associated theorems, thermodynamic potentials and their physical interpretations, and three distribution functions.
2. Have basic knowledge of Ising model, quantum mechanical ensembles, Bose & Fermi systems, critical phenomena, and phase transition.
3. Be able to
   ii. Answer/solve questions/problems related to
      e) Thermodynamic functions (enthalpy, Gibb's free energy, Helmholtz function).
      f) M-B, B-E, and F-D statistics/distribution functions.
   iii. Apply the concept of M-B, B-E, and F-D statistics/distribution functions in other domains (*e.g.*, solid state physics, quantum mechanics, mathematical physics, and nuclear physics).
   iv. Pursue research in theoretical physics/mathematical physics/applied mathematics.
   v. Apply the concept of entropy in social/economic problems – understanding of sociophysics.
3. Have deep understanding of kinetic theory of gas and influence of M-B statistics/distribution function in understanding various properties of a gas.
4. Have critical knowledge required for pursuing research in statistical mechanics, astrophysics.

Statistical basis of thermodynamics: Entropy & disorder, concept of macro- & micro-states, contact between statistics and thermodynamics- physical significance of the number Ω (N,V,E), relation between entropy and thermodynamics probability (microstate), i,e,, $S = K_B \ln\Omega$, phase space, μ-space & Γ-space, postulate of equal a priori probability, concept of ensemble (microcanonical, canonical, &

grand-canonical ensembles), Ergodic hypothesis (mean value over an ensemble & mean value over time).

M-B, B-E, & F-D statistics & distribution functions: Detail discussion of M-B, B-E, and F-D statistics and distribution functions, differences among them, thermal de Broglie wave length, partition function, molecular partition function (rotational, vibrational, & electronic), enthalpy (H), Gibb's free energy (G), Helmholtz function (A), chemical potential (μ), & their relations, thermal equilibrium, Brief idea - symmetric & anti-symmetric wavefunctions, Pauli exclusion principle, density of states, electron gas in metals, & B-E condensation (qualitative).

Kinetic Theory of Gases: Basic assumptions of kinetic theory of gases, Maxwell velocity distribution, momentum distribution, energy distribution, experimental verification of Maxwell distribution (Stern's experiment, free fall under gravity), Doppler broadening of spectral lines mean, rms and most probable speeds, degrees of freedom, law of equipartition of energy (no proof required), specific heats of gases, mean free path, collision cross-section, collision probability, estimates of mean free path.

Transport Phenomenon: Diffusion, Brownian motion and its significance.

Phase: Concept of phase, component, fusion, vaporization, sublimation, degrees of freedom, critical point, & triple point, change of phase, Gibbs phase rule, first- & second-order phase transition, brief idea of lambda (λ) transition (He-I & He-II).

Classical Theory of Radiation: Properties of thermal radiation, blackbody radiation, Kirchhoff's law, Stefan-Boltzmann law, radiation pressure, Wien's displacement law, Wien's Distribution Law, Saha's ionization formula, Rayleigh-Jean's law, ultraviolet catastrophe.

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation, Planck's Quantum Postulates, Planck's Law of Blackbody Radiation: Experimental Verification, Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Introduction to Modern Physics – R.B. Singh.
2. Statistical Mechanics – R.K. Pathria.
3. Statistical Mechanics – K. Huang.
4. Thermal Physics. Kinetic Theory. and Statistical Mechanics – S.C. Garg. R.M. Bansal. & C.K. Gosh.
5. Thermal Physics – Entropy and Free Energies – J.C. Lee.
6. Introduction to Modern Statistical Mechanics – D. Chandler.
7. Fundamentals of Statistical and Thermal Physics – F. Reif.
8. Thermodynamics. Kinetic Theory. and Statistical Mechanics – S. Salinger and G.L. Salinger.

9. Physics for Scientists and Engineers with Modern Physics – R.A. Serway & J.W. Jewett. Thomson.
10. Physics for Scientists & Engineers with Modern Physics – Giancoli.
11. Conceptual Physics – P.G. Hewitt. Pearson.
12. Physics for Scientists & Engineers with Modern Physics – P.M. Fisbane. S.G. Gasiorowicz. & S.T. Thornton. Pearson.
13. Modern Physics – P. Tipler & R.A. Lllewellyn.
14. Modern Physics – A. Beiser.

Physics Lab. – VI

Course Objectives:
1. Verify concept of modern physics through experiments.
2. Provide hands-on training on various advanced equipments.

Learning Outcomes: After completion of the course learners will be able to
1. Analyze experimental results/data using Origin software.
2. Set-up physics/applied physics experiment.
3. Handle sophisticated instrument.
4. Pursue research in applied science.

List of suggested experiments: [*NOTE*: Topics not covered in lectures should be discussed at the time of demonstration during lab. hours]

1. Blackbody radiation.
2. Brownian motion.
3. Heat engine.
4. Fiber optics.
5. Holography.
6. Polarization. optical rotation. Kerr effect. and Faraday effect.
7. Large amplitude pendulum.
8. Non-linear oscillation and chaos.
9. Coriolis and centripetal acceleration and force.
10. Foucault pendulum.
11. Angle of contact.
12. Gravitational Torsion Balance.
13. Experiment with waves and oscillations.
14. Raman spectroscopy.
15. Luminescence experiment.
16. UV-VIS spectroscopy.
17. Atomic force microscopy.
18. Experiments decided by lab. instructor.

Discipline Specific Electives (Physics)

(Take any two electives from the following list of courses)

BPH610 - Introduction of Nanotechnology
BPH611- Mechanics II
BPH612 - Major Project / Dissertation
BPH613 - Nanomaterials and Nanophysics
BPH614 - Fundamentals of Laser and Laser Spectroscopy
BPH615 - Advanced Quantum Mechanics
BPH616 - Materials Characterization Techniques
BPH617- Introduction to Astronomy and Astrophysics

BPH610- Introduction to Nanotechnology

Course Objectives:

1. Provide knowledge of systems with physical dimension down to nanometer scale.
2. Dimension specific size restriction of materials and emergence of new properties of matter.
3. Provide knowledge of three-dimension, two-dimension, one-dimension and zero-dimension systems.
4. Provide knowledge of preparation and characterization of materials with sizes several nanometers.

Learning Outcomes: After completion of the course, learners will be able to

1. Understanding of the bulk materials and nanomaterials and difference between them.
2. Apply the concept of dimension specific properties of various nanomaterials.
3. Acquired knowledge on the various preparation techniques and characterization tools of nanomaterials.
4. Acquired knowledge on the importance of the nanotechnology in the present era.

Introduction of Nano and size matters, The Fundamental Science Behind Nanotechnology- Electrons, Atoms and Ions, Molecules, Electrical Conduction and Ohm's Law and Quantum Mechanics and Quantum Ideas in nanoscale, understanding different Nanoscopic phenomenon.

Zero-Dimensional Nanostructures: Nanoparticles, One-Dimensional Nanostructures: Nanorods and Nanowires, Two-Dimensional Nanostructures: Thinfilms, Special Nanomaterials

Tools of the Nanosciences -Tools for Measuring Nanostructures, Tools to Make Nanostructures

Smart materials and Nanotechnology, Biomedical applications, Nanotechnology for better lifestyle. Nanotechnology and you.

Scope of the syllabus is defined from following recommended books:

1. Introduction to Nanotechnology Paperback – Frank Owens and Charles Poole
2. Nanostructures and Nanomaterials—G Cao
3. Nanotechnology: A Gentle Introduction to the Next Big Idea – M Ratner and D Ratner
4. Introduction to Nanotechnology -- Risal Singh & Shipra Mital Gupta
5. An Introduction to Nanoscience and Nanotechnology-- Alain Nouailhat

BPH611- Mechanics – II

Course Objectives:

1. Provide knowledge of system of particles, rotational motion, and gravitation.
2. Acquaint students with the basic concept of
   i. Rotating coordinate system.
   ii. Variational principle.
   iii. Central force.
   iv. Lagrangian and Hamiltonian formulations.
3. Orient students with the simple applications of Lagrangian and Hamiltonian formulations.
4. Make students understand the basic concepts of Canonical Transformations and Poisson brackets and their properties.

Learning Outcomes: After completion of the course, learners will be able to

1. Apply the concept of conservation of linear momentum, energy and angular momentum in various classical systems.
2. Apply the concept of central force in planetary motion.
3. Construct Lagrangian and Hamiltonian of physical systems (classical and quantum mechanical).
4. Describe basic concepts of canonical transformation, Poisson brackets and properties of Poisson brackets.
5. Transform the coordinates and variables in generalized coordinate system.
6. Apply the concept of small oscillation to physical systems.
7. Answer questions and solve problems related to
   v. System of particles, rotational motion, gravitation.
   vi. Central forces including Keplar problems.
   vii. Hamiltonian & Lagrangian formulations.

Rotating Co-ordinate System: Non-inertial coordinate systems, rotating coordinate systems, derivative operators, velocity and acceleration in a moving system, Coriolis and centripetal acceleration and force, motion of a particle relative to the earth, Foucault pendulum.

Variational Principles and Lagrange's Equations: Hamilton's principle, some techniques of the calculus of variations, derivation of Lagranges's equations from Hamilton's principle, extension of Hamilton's principle to nonholonomic systems, advantages of variational principle formulation, conservation theorems & symmetry properties, energy functions & the conservation of energy.

The Central Force Problem: Reduction to the equivalent one-body problem, equations of motion & first integrals, equivalent one-dimensional problem & classification of orbits, virial theorem, differential equation for the orbit & integrable power-law potentials, conditions for closed orbits (Bertrand's theorem), Kepler problem, motion in time in Kepler problem, Laplace-Runge-Lenz vector, scattering in central force field, transformation of scattering problem to lab, coordinates, three-body problem.

The Hamilton Equations of Motion: Legendre transformations & the Hamilton equations of motion, cyclic coordinates & conservation theorem, Routh's procedure, Hamiltonian formulation of relativistic mechanics, derivation of Hamilton's equations from variational principle, principle of least action.

Canonical Transformations: Equations of canonical transformation, examples of canonical transformations, harmonic oscillator, symplectic approach to canonical transformations, Poisson backets & other canonical invariants, equations of motion, infinitesimal canonical transformations, & conservation theorems in the Poisson bracket relations, symmetry groups of mechanical systems, Liouville's theorem.

Problems & exercises pertaining to above topics from recommended books form an integral part of the paper.

Scope of the syllabus is defined from following recommended books:

1. Classical Mechanics – H. Goldstein. C. Poole. & J. Safko.
2. Classical Mechanics – N.C. Rana & P.S. Joag.
3. Theory and Problems of Theoretical Mechanics – M.R. Spiegel (Schaum series).
4. Introduction to Classical Mechanics – R.G. Takwale & P. Puranik.
5. Classical Mechanics of Particles and Rigid Bodies – K.C. Gupta.
6. A student's Guide to Lagrangian and Hamiltonian – P. Hamill.
7. Classical Mechanics – R. D. Gregory.

BPH613 - Nanomaterials and Nanophysics

Course Objectives:
1. Provide knowledge of systems with physical dimension down to nanometer scale and the physics behind them.
2. Provide knowledge of the Energy quantization, size effect and quantum phenomenon.
3. Exposure to three-dimension, two-dimension, one-dimension and zero-dimension systems.
4. Provide knowledge of characterization of nanomaterials.

Learning Outcomes: After completion of the course, learners will be able to
1. Understanding of the energy quantization and physics behind interesting properties of materials with different dimension restriction.
2. Apply knowledge to know-how of several sophisticated instruments to see the inside of the nanoworld.

Wave function, Quantum confinement, two dimensional, one dimensional and zero dimensional systems, Energy quantization and quantum phenomena. Zero-Dimensional Nanostructures:

Nanoparticles, One-Dimensional Nanostructures: Nanorods and Nanowires, Two-Dimensional Nanostructures: Thinfilms, Special Nanomaterials

Phenomena at nanoscale: Nanoscale electrical transport, nano- magnetics, nanoscale thermal transport.

Nanomaterial systems: Metallic, semiconducting, Quantum dot and quantum superlattice, polymer, nanocomposites, carbon based nanostructures, nanowires, photonic crystals, self-asembled nanostructures.

Synthesis of nanomaterials: clusters, particles, rods and wires, nanostructures

Characterization of nanomaterials: X-ray diffraction, transmission electron microscopy, Scanning electron microscopy, Scanning near- field optical microscopy, other Scanning probes for imaging and manipulation, optical and vibrational spectroscopy, electrical, magnetic and electrochemical methods.

Applications of nanomaterials in electronics, photonics, biotechnology, nanoelectromechanical systems (NEMS).

References:

1. Nanomaterials: Synthesis, properties and Applications, Ed. A. S. Edelstein and R.C.Cammarata, IOP.
2. Nanostructures and Nanomaterials—G Cao
3. Characterization of nanophase materials: Ed. Z. L. Wang, Willey-VCH.
4. Introduction to nanotechnology, Charles P. Poole and Frank J. Owens (Wiley- Interscience).
5. Naostructured Materials, Ed. Jackie Yi-Ru Ying (Academic Press).
6. Nanotechnology: Basic Science and emerging technologies, Ed. Michael Wilson, K.Kannangara, G. Smith, M. Simmons, and C. Crane (CRC Press).

BPH614 - Fundamentals of Laser and Laser Spectroscopy

Course Objectives:

1. Provide knowledge of lasing action of materials and requirements for LASER.
2. Provide knowledge of the basic of LASERS and various pulsing techniquies.
3. Exposure to various types of LASER systems and their operations.
4. Provide knowledge of applications of LASERS.

Learning Outcomes: After completion of the course, learners will be able to

1. Understanding of the lasing action and requirements for a successful LASER.
2. Apply knowledge to know-how of several LASER systems and their applications in various area.
3. Apply knowledge to use and improve the present day LASER technology.

Introduction to LASERs - LASERs and its history, Interaction of Light with matter, The Einstein coefficients, light amplification, the threshold condition, laser rate equations

Basics of LASERs- Concept of population inversion, 2-level, 3-level, and 4-level systems, Components of LASERs, Threshold condition, various parameters of a LASER

Pulsing techniques- Cavity damping, Q-switching, mode locking in lasers

Types of LASARs- gas lasers, solid state lasers, semiconductor lasers and dye lasers etc.

Applications of Lasers: Non-linear optics, LIDAR, Laser spectroscopy, Applications of LASARs in Material sciences and engineering, Optical Communications, industry and medical science, LASAR safety.

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Book reference-

1. W. T. Silfvast, Laser Fundamentals, 2nd Ed., Cambridge University Press.
2. B.E.A. Saleh and M.C.Teich, Fundamentals of Photonics, 2nd Ed., Wiley.
3. Lasers, Oxford -- A. E. Seigman.
4. Laser Spectroscopy Basic Concepts and Instruments, W. Demtroder, Springer
5. Foundations of laser spectroscopy, S. Stenholm, Wiley.
6. Atom Optics with Laser Light -- V. I. Balykin and V. S. Lethokov, Harwood Academic Publishers.
7. Laser Spectroscopy-- Wolfgang Demtröder, Springer.

BPH615 - Advanced Quantum Mechanics

Course Objectives: To impart knowledge of

1. advanced topics of quantum mechanics: time-independent and time-dependent perturbation effects to quantum systems.
2. Provide knowledge of fundamental concepts of the relativistic quantum mechanics.

Learning Outcomes: After completion of the course, learners will be able to

1. Understanding of the effects of several external disturbance to the quantum systems.
2. Apply the knowledge to predict the behaviour of quantum systems under various perturbation conditions.

One dimensional trivia: The -function potential, Scattering: phase shift, partial waves, • Bounds states vs. pole in S-matrix, Double function, attractive/repulsive, Periodic array of -functions (Dirac's comb) as a model for lattice. Band structureThis course introduces a student to relativistic quantum mechanics. It includes the Dirac equation and an introduction to quantum electrodynamics.

Time-independent perturbation theory: Rayleigh-Schr¨odinger method for bound states, R-S perturbation theory for degenerate states, Convergence issue, Asymptotic series and Borel resummation

Time-dependent perturbation theory: Time-evolution formula in Dirac's picture, Transition to continuum and Fermis's golden rule, Propagators and diagrams, Feynman rules and combinatorial factors

Introduction to relativistic quantum mechanics: Lorentz group and its representations (scalar, vectors, tensors and spinors), The Klein-Gordon equation, The Dirac equation and Cliford algebra (-matrixology), Coupling to electromagnetism, Central field problem: exact solution, Hydrogen atom and hyperfine structure, Discrete symmetries: parity, charge reversal, time reversal.

Book References:

1. A First Book in Quantum Field Theory, Amitabha Lahiri and Palash B. Pal, Alpha Science International
2. Relativistic Quantum Mechanics-- W. Greiner and D.A. Bromley (Springer, Berlin)
3. Advanced Quantum Mechanics-- J. J. Sakurai, Addison Wesley, London
4. Quantum Field Theory-- C. Itzykson, J.-B. Zuber, Dover Publications, London
5. An Introduction to Quantum Field Theory, M. E. Peskin and D. V. Schroder, Westview Press

BPH616 - Materials Characterization Techniques

Course Objectives:

1. Provide knowledge of various types of sensors for measurement of different properties of materials towards the development of automation technology.
2. Provide knowledge of techniques to achieve low temperature and low pressure envirnments required for specific scientific experiments and/or in industry.
3. Exposure to several Analytical Instruments.

Learning Outcomes: After completion of the course, learners will be able to

1. Understanding of the sensor technology.
2. Apply knowledge to create a low pressure and low temperature environment as per requirement at research lab or industry.
3. Got exposure to various analytical experimental tools for the characterization of materials.

Sensors: Resistive, capacitative, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors; interfacing sensors and data acquisition using serial and parallel ports.

Low pressure: Rotary, sorption, oil diffusion, turbo molecular, getter and cryo pumps; Mcleod, thermoelectric (thermocouple, thermister and pirani), penning, hot cathode and Bayard Alpert gauges; partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components.

Low temperature: Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

Analytical Instruments: X-ray diffractometer; Spectrophotometers; FT-IR; DSC; lock-in amplifier; spectrum analyzer, fluorescence and Raman spectrometer, scanning electron microscope, atomic force microscope, Transmission Electron Microscope.

References books

1. Modern electronic instrumentation and measurement techniques -- A. D. Helfrick and W. D. Cooper, Prentice Hall of India.
2. Principles of measurement systems -- J. P. Bentley, Longman.

3. Experimental techniques in low temperature physics-- G. K. White Calrendon.
4. Vacuum technology, A. Roth, Elsevier.
5. Basic Vacuum Technology, Chambers A., et al.
6. D. A. Skoog, F. J. Holler and T. A. Nieman, *Principles of Instrumental analysis,* Saunders CoIl. Publ..

BPH617 - Introduction to aAstronomy and Astrophysics

Course Objectives:

1. Skills to learn and operate astronomical instruments to perform observations related to the positional astronomy measurement.
2. Conceptualize skills to understand basic parameters for describing the properties of stars and making experimental measurements, their interpretation and role in understanding of astrophysical phenomenon. Study of solar and stellar spectra.
3. Learn to describe solar parameters, solar atmosphere, origin of solar system, solar and extra-solar planets, planetary rings.
4. Acquire basic knowledge of Milky Way and Galaxies, their properties and structure.
5. Skills for understanding basics of large-scale structures and expending universe.

Course learning outcome:

1. Ability to comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and measurement of distances, time and temperature and radius of star.
2. Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram
3. Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes.
4. Understanding Physics of sun and solar system: photosphere, chromosphere, corona, solar activity. Solar MHD, helioseismology, solar system and its origin. Nebular model. Tidal forces and planetary rings.
5. Understanding Physics of stars and sun. Role of gravitation in astroPhysics, Newton vs Einstein, viral theorem and thermodynamic equilibrium. Atomic spectra, stellar spectra. Spectral classification, luminosity classification, temperature dependence.
6. Acquire basic knowledge of galaxies and Milky Way. Morphology and classification of galaxies, intrinsic stages of galaxies, galactic halo, milky way, gas and dust in galaxy, spiral arm, rotation of galaxy and dark matter. Star clusters in Milky Way, galactic nucleus and its properties.
7. Learn about the large scale structure and expanding universe cosmic distance ladder, distance measurements, cluster of galaxies, Hubble's law.

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness,Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. **Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

Astronomical techniques: Basic Optical Definitions for Astronomy (MagnificationLight Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes). **Physical principles:** Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere.Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). **The solar family** (Solar System: Facts and Figures, Origin of the Solar System: TheNebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.
Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)

The milky way : Basic Structure and Properties of the Milky Way, Nature of Rotation ofthe Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

Galaxies: Galaxy Morphology, Hubble’s Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble’s Law (DistanceVelocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

Reference Books:

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Private limited, New Delhi,2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Skill Enhancement Course (SEC) - 4

Applied Optics

Course Objectives:
This course will help in understanding about the lasers and detectors, Holography, Optical fibre and their applications.

Course learning outcome:
This course will enable the student to get

1. Familiar with optical phenomena and technology.
2. Qualitative understanding of basic lasing mechanism, types of Lasers, characteristics of Laser Light, types of Lasers, and its applications in developing LED, Holography.
3. The idea of propagation of electromagnetic wave in a nonlinear media – Fibre optics as an example will enable the student to practice thinking in a logical process, which is essential in science.
4. Experiments in this course will allow the students to discuss in peer groups to develop their cooperative skills and reinforce their understanding of concepts.

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

(i) Sources and Detectors
Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.
Experiments on Lasers:
a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
b. To find the width of the wire or width of the slit using diffraction pattern obtained by a HeNe or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser
Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor

(ii) Fourier Optics

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

a. Fourier optic and image processing

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

(iii) Holography

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

(iv) Photonics: Fibre Optics

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre
c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern

d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre

Reference Books:

1. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
2. ASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
6. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
8. Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

Radiation Safety

Course Objectives: This course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics.
1. General concepts of nuclei, nuclear forces and atomic physics are studied.
2. Basic knowledge about nuclear radiation types and radiation detectors.

Course learning outcome:

1. Be aware and understand the hazards of radiation and the safety measures to guard against these hazards.
2. Revise or learn the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.
3. Have a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.
4. Know about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.
5. The students are expected to learn 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) its principles, justification, optimization, limitation, introduction of safety and risk management of radiation. nuclear waste and disposal management, brief idea about ‘Accelerator driven Sub-critical System’ (ADS) for waste management.
6. Learn about the devices which apply radiations in medical sciences, such as MRI, PET.
7. The students are expected to do the following experiments: (i) Study the background radiation levels using Radiation meter , (ii) Characteristics of Geiger Muller (GM) Counter, getting the plateau curve and the operating voltage and the statistical distribution of beta or gamma ray emitted from a radioactive source.

8. Determination of gamma ray linear and mass absorption coefficient of a given material, and drawing the mass absorption coefficient vs. energy curve for a given material with a number of gamma ray sources, (v)study of beta ray energy spectrum for a given source.

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

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons** - Photo-electric 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: Basicidea 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 ProportionalCounters (MWPC) and Gieger 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), Archaeology, Art, Crime detection, Mining and oil. *Industrial Uses:* Tracing, Gauging, Material Modification, Sterization, Food preservation.

Experiments:

1. Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:

2) Study of characteristics of GM tube and determination of operating voltage and plateau length sing background radiation as source (without commercial source).

3) Study of counting statistics using background radiation using GM counter.

4) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.

5) Study of absorption of beta particles in Aluminum using GM counter.
6) Detection of α particles using reference source & determining its half life using spark counter

Reference Books

1. W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. G.F.Knoll, Radiation detection and measurements
3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.
5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.
9. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

Syllabus of Mathematics Papers

Semester – I

Calculus

Course Objectives: Provide mathematical knolwedge required for physics

1. Real numbers.
2. Various types of series and sequences.
3. Properties of function – limit and continuity.
4. Asymptotes in Cartesian and polar coordinates.
5. Curvatures, concavity and convexity of functions.

Learning Outcomes: After completion of the course, learners will be able to

1. Apply the concept in various branches of science.
2. Concepts in other mathematical physics

Real Number System: Introduction, Historical background, Integers and rational numbers, Completeness property of real number system, Archimedean property, supremum and the infimum.

Sequences and Series: Definition, Convergence of a sequence, Boundedness of a sequence, Monotone sequences, Sandwich Theorem, Cauchy's criterion, Nested interval Theorem, Bolzano-Weierstrass theorem.

Limit and Continuity: Definition (ε and δ definition), Continuity of a function at a point in terms of sequences, Continuous function on a subset of real numbers, Limits at Infinity, Properties of Continuous Functions on a Closed Interval, Existence of Maxima, Intermediate Value Property. Discontinuous functions, Types of discontinuities.

Differentiability: Differentiability of functions, Rolle's Theorem, Mean Value Theorem, Cauchy Mean Value Theorem, Successive differentiation, Leibnitz's theorem, L'Hospital Rule, Extended Mean Value Theorem, Taylor's theorem with Lagrange's and Cauchy's forms of remainder. Maclaurin's series of sin x, cos x, e^x, log(l+x), $(1+x)^m$, Partial differentiation, Euler's theorem on homogeneous functions.

Asymptotes: Asymptotes in Cartesian coordinates, Intersection of curve and its asymptotes in polar coordinates.

Curvature: Curvature, Radius of curvature for Cartesian curves, parametric curves, polar curve, Newton's method, Radius of curvature for pedal curves, Tangential polar equation, Centre of curvature, Circle of curvature, Chord of curvature, evolutes.

Concavity and Convexity: Test for concavity and convexity, Points of inflexion, Multiple points, Cusps, nodes and conjugate points, Types of cusps.

Tracing of curves: Tracing of curves in Cartesian, parametric and polar coordinate.

Books Recommended:

1. P. M. Fitzpatrick, Advanced Calculus, 2nd Ed., AMS, Indian Edition, 2010.
2. N. L. Carothers, Real Analysis, Cambridge University Press, Indian Edition, 2009.
3. J. E. Marsden and M. J. Hoffman, Elementary Classical Analysis, 2nd Edn., W. H. Freeman, 1993.
4. W. Rudin, Principles of Mathematical Analysis, 3rd Ed., McGraw Hill, 1976.
5. R.G. Bartle & D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons Pvt. Ltd., 2000.

Semester – II

Integral Calculus and Differential Equations

Course Objectives: To acquaint the students with the basic concept of
1. Integration and reduction formulae rectification, quadrature.
2. Differential equations and exact differential equations
3. Higher order differential equations.
4. Series solutions of linear differential equations.
5. Differential equations of first order and second order.

Learning Outcomes: After completion of the course the learners will
1. Have fundamental knowledge about the topics and their possible applications.

2. Be able to
    i. Solve basic and conceptual problems.
    ii. Apply the concepts in other branches of science.

Integral Calculus

Integration and Reduction Formulae: Integration by Partial fractions, integration of rational and irrational functions. Properties of definite integrals. Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic, Beta and Gamma functions and of their combinations.

Rectification: Length of arc, Fundamental theorem about Rectification, Length of the Parametric Curves, Length of the Polar Curves. Intrinsic Equation of a curve, Derivation of the intrinsic equation of a curve from the parametric equations and from the pedal equation.

Quadrature: Introduction, Area between two Curves, Area formula for Parametric Curves, Polar Curves, Area between two Polar Curves.

Differential Equations

Differential Equations: Classification of Differential Equations; Their origin and applications, Solutions, Initial Value Problems, Boundary Value Problems, and existence of solutions.

First Order Exact Differential Equations: Exact Differential Equations and Integrating factors, rules to find an integrating factor, First order higher degree equations solvable for x, y, p. Separable equations and equations reducible to this form. Linear Equations and Bernouilli, Special integrating factor and transformation.

Application of First-Order Differential Equations: Orthogonal and oblique trajectories, problem in mechanics, Rate problems.

Methods for Solving Higher-Order differential equations. Basic theory of linear differential equations, The homogeneous linear Differential Equations with constant coefficients, The method of undetermined coefficients, The Cauchy-Euler equation, Wronskian, and its properties. Solving a differential equation by reducing its order, Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, Simultaneous differential equations, Total differential equations.

Series Solution of Linear Differential Equations: Power Series solution about an ordinary point, Solution about singular points, The method of Frobenius, Bessel’s Equation and Bessel Functions, Legendre’s differential equation, Hermite polynomial, Laguerre's equation.

Approximate Methods of Solving First Order Equations: Graphical Methods, Power Series Methods, The Method of Successive Approximations, Numerical Methods.

Partial Differential Equations of The First Order: Order and degree of partial differential equations, Origin of the First order PDEs, Formation of first order partial differential equations, Cauchy's problem for first order Equations, Linear equation for the first order, Lagrange's method, Charpit's method.

Second Order Partial Differential Equations: Origin of the Second order PDEs, Classification of second order partial differential equations into elliptic, parabolic and hyperbolic, Second Order Equations in Physics, Higher Order Equations in Physics.

Book Recommended:

1. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 1990.
2. S. L. Ross, Differential Equations, 3^{rd} Ed., Wiley India, 1984.
3. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
4. F. John, Partial Differential Equations, Springer, 1982.
5. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.
6. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
7. F. Brauer and J. A. Nohel, The Qualitative Theory of Ordinary Differential Equations: An Introduction, Dover Publications, 1969.

Semester – III

Real Analysis

Course Objectives: To orient students with

1. Basic results of sets and real number system.
2. Series and convergence tests of a series.
3. Sequence of functions.
4. Functions of several variables.
5. Matrices and norms.

Learning Outcomes: After completion of the course the learners will

1. Have conceptual knowledge of sets, series, and functions.
2. Be able to
    - iii. Solve basic and conceptual problems.
    - iv. Apply the concepts in other branches of science.
    - v. Able to handle challenging problems.
    - vi. Pursue higher studies in mathematical physics.

Introduction: Finite and infinite sets, examples of countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals, Concept of cluster points and Bolzano Weierstrass theorem.

Series: Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's test, Tests of Convergence. Definition and examples of absolute and conditional convergence.

Sequence of Functions: Sequences and series of functions, Pointwise and uniform convergence, M_n-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

Functions of Several Variables: Limit, continuity, partial and directional derivatives, differentiability, chain rule, Taylor's theorem, inverse function theorem, implicit function theorem, maxima and minima, multiple integral, change of variables, Fubini's theorem.

Metrics and Norms: Metric spaces, convergence in metric spaces, completeness, compactness, contraction mapping, Sequences and series of functions, uniform convergence, uniform continuous functions, equicontinuity.

Books Recommended:

1. T. M. Apostol, Calculus (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd., 2000.
3. E. Fischer, Intermediate Real Analysis, Springer Verlag, 1983.
4. K.A. Ross, Elementary Analysis: The Theory of Calculus Series, Undergraduate Texts in Mathematics, Springer Verlag, 2003.
5. S. Kumaresan, Topology of Metric Spaces, Second Edition,Narosa Publishing House, 2011.

Semester – IV

Algebra

Course Objectives: To impart knowledge about
1. Functions and mapping.
2. Set theory.
3. Various groups and sub-group and their properties with suitable examples.
4. Rings and ideals with examples.

Learning Outcomes: After completion of the course the learners will
1. Have fundamental knowledge about the topics.
2. Be able to
   i. Understand relevant topics.
   ii. Concepts in other branches of science.
   iii. Answer and solve conceptual questions & problems.

Preliminaries: Properties of Integers, Modular Arithmetic, Mathematical Induction, Equivalence Relations, Functions (Mappings).

Set Theory: Sets, subsets, Set operations, the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Groups: Definition and examples of groups, examples of abelian and non-abelian groups, Finite Groups, the group Z/nZ of integers under addition modulo n and the group U(n) of units under multiplication modulo n. Cyclic groups from number systems, complex roots of unity, circle group, the general linear group $GL_n(n,R)$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions.

Subgroups: Definition, Subgroup test, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Cosets, Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.

Homomorphism and Isomorphism: Definition of Group Homomorphism, Properties of Homomorphism, Group Action, Definition and examples of Isomorphism, Cayley's Theorem, Automorphism, Isomorphism Theorems, Sylow's Theorems.

Rings and Fields: Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, The ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings, Ideals, Maximal, Prime and Principle ideals, Integral domains and fields, examples of fields: Z/pZ, Q, R, and C. Field of rational functions.

Books Recommended:

1. D. Dummit and R. Foote, Abstract Algebra, Wiley, 2004.
2. N. McCoy and G. Janusz, Introduction to Abstract Algebra, 7^{th} En.,Trustworthy Communications, Llc, 2009.
3. I.N. Herstein, Topics in Algebra, Wiley, 2008.
4. J. Fraleigh, A First Course in Abstract Algebra, Pearson, 2003.
5. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1995.

Semester – V

Skill Enhancement Course (SEC) – 3

Number Theory

Course Objectives:

1. To acquaint the students with the
    i. Fundamental theorem of arithmetic.
    ii. Basic concepts of Diophantine equations.
2. To orient the students with
    i. Basic concept of congruences.
    ii. Different types of number theoretic functions.

Learning Outcomes: After completion of the course the learners will

1. Have fundamental knowledge about the topics.
2. Be able to apply the concepts in other branches of science.
3. Be able to solve conceptual questions & problems.

Division algorithm, Lame's theorem, linear Diophantine equation, fundamental theorem of arithmetic, prime counting function, statement of prime number theorem, Goldbach conjecture, binary and decimal representation of integers, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Möbius inversion formula, the greatest integer function, Euler's phi-function.

Books Recommended:

1. David M. Burton, Elementary Number Theory 6^{th} Ed., Tata McGraw-Hill Edition, Indian reprint, 2007.
2. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, Applications of Abstract Algebra with Maple, CRC Press, Boca Raton, 2000.
3. Neville Robinns, Beginning Number Theory, 2^{nd} Ed., Narosa Publishing House Pvt. Limited, Delhi, 2007.

Semester – VI

Skill Enhancement Course (SEC) – 4

Graph Theory

Course Objectives: To impart conceptual knowledge of

1. Graphs - definition and examples.
2. Isomorphism theorem of graphs.
3. Various graphs – pseudographs, complete graphs, bi-partite graphs.

4. Shortest path.
5. Travelling salesman's problem.
6. Dijkstra's algorithm & Floyd-Warshall algorithm.

Learning Outcomes: After completion of the course the learners will
1. Have fundamental knowledge about various types of graphs.
2. Path and circuit..
3. Algorithms related to graphs.
4. Be able to solve conceptual questions & problems.

Definition, Examples and basic properties of graphs, Pseudographs, Complete Graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Books Recommended:

1. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory 2nd Ed., Pearson Education (Singapore) Pvt. Ltd., Indian Reprint, 2003.
2. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
3. Kenneth Rosen, Discrete Mathematics and Its Applications, 7th Ed., McGraw-Hill, 2014.

Syllabus of Computer Science Papers

Semester-I

Programming using C

Learning Objectives:
The course is designed to provide complete knowledge of C language. Students will be able to develop logics which will help them to create programs, applications in C. To introduce programming skills to students with the basic syntax of C programming language Also by learning the basic programming skills they can easily switch over to any other language in future.

Learning Outcomes: After completion of this course successfully the students will be able to:
1. Understand & implementation of functional hierarchical code organization.
2. Define and manage data structures based on problem subject domain.
3. Work with textual information, characters and strings.
4. Work with arrays of complex objects.
5. Implement a defensive programming concept.
6. Handle possible errors during program execution**.**

1. Introduction to C : History of C, Overview of Procedural Programming, Using main() function, Compiling and Executing Simple Programs in C.

2. Data Types, Variables, Constants, Operators and Basic I/O : Declaring, Defining and Initializing Variables, Scope of Variables, Using Named Constants, Keywords, Data Types, Casting of Data Types, Operators (Arithmetic, Logical and Bitwise), Using Comments in programs, Character I/O (getc, getchar, putc, putcharetc), Formatted and Console I/O (printf(), scanf(),), Using Basic Header Files (stdio.h, conio.hetc).

3. Expressions, Conditional Statements and Iterative Statements : Simple Expressions in C (including Unary Operator Expressions, Binary Operator Expressions), Understanding Operators Precedence in Expressions, Conditional Statements (if construct, switch-case construct), Understanding syntax and utility of Iterative Statements (while, do-while, and for loops), Use of break and continue in Loops, Using Nested Statements (Conditional as well as Iterative)

4. Functions and Arrays : Utility of functions, Call by Value, Call by Reference, Functions returning value, Void functions, Inline Functions, Return data type of functions, Functions parameters, Differentiating between Declaration and Definition of Functions, Command Line Arguments/Parameters in Functions, Functions with variable number of Arguments.
Creating and Using One Dimensional Arrays (Declaring and Defining an Array, Initializing an Array, Accessing individual elements in an Array, Manipulating array elements using loops), Use Various types of arrays (integer, float and character arrays / Strings) Two-dimensional Arrays (Declaring, Defining and Initializing Two Dimensional Array, Working with Rows and Columns), Introduction to Multi-dimensional arrays

5. Derived Data Types (Structures and Unions) : Understanding utility of structures and unions, Declaring, initializing and using simple structures and unions, Manipulating individual members of structures and unions, Array of Structures, Individual data members as structures, Passing and returning structures from functions, Structure with union as members, Union with structures as members

6. Pointers in C: Understanding a Pointer Variable, Simple use of Pointers (Declaring and Dereferencing Pointers to simple variables), Pointers to Pointers, Pointers to structures, Problems with Pointers, Passing pointers as function arguments, Returning a pointer from a function, using arrays as pointers, Passing arrays to functions. Pointers

7. Memory Allocation in C: Differentiating between static and dynamic memory allocation, use of malloc, calloc and free functions, use of new and delete operators, storage of variables in static and dynamic memory allocation

8. File I/O, Preprocessor Directives : Opening and closing a file, Reading and writing Text Files, Using put(), get(), read() and write() functions, Random access in files, Understanding the Preprocessor Directives (#include, #define, #error, #if, #else, #elif, #endif, #ifdef, #ifndef and #undef), Macros

Recommended Books:

1. E. Balaguruswami, Programming in ANSI C, Tata Mc-Graw Hill.
2. Yashwant Kanetker, Let us C, BPB Publications.
3. Gottfried, Programming with C, Tata McGraw Hill
4. Brian W. Kernighan, Dennis M. Ritchie, The C Programming Language, 2nd Ed., PHI.

Semester-II

<u>Object Oriented Programming</u>

Learning Objectives:
1. To learn advanced features of the C++ programming language.
2. To learn the characteristics of an object-oriented programming language.
3. To learn the basic principles of object-oriented design.
4. To enhance problem solving and programming skills in C++.

Learning Outcomes: On completion of the course students should be able to:
1. Implement various features of C++ supporting object oriented programming in computer programs.
2. Explain the relative merits of C++ as an object oriented programming language
3. To produce object-oriented small- small software using C++
4. Apply the major object-oriented concepts to implement object oriented programs in C++, encapsulation, inheritance and polymorphism
5. Implement advanced features of C++ specifically stream I/O, templates and operator overloading

Introduction to OOP : Programming paradigms, Structured / Procedural Programming, Object Oriented Programming, Characteristics of Object Oriented Programming. Introduction to C++: Character set of C++, Identifiers, Keywords, Variables and Constants; Basic Data Types, User defined and Derived data types

Operators in C++: Unary, Binary and ternary operators; Arithmetic, logical, relational, bitwise operators, Assignment Operators; Type conversion, & Scope resolution operator, Memory Management Operators (new, delete), Reference Variable / Operator

Control Structure in C++ : Decision Statements: If and switch statements, Repetitive Statements: do-while, while and for loop; Jumping Statements: break, continue, exit, goto statements.
Functions in C++ : The main function, Function prototyping, default arguments, const arguments, call by reference and return by reference; Inline function, Static data & member function, const member function, friend functions & friend classes

Arrays and Strings: Types of arrays, array declaration, Operations on arrays, and string manipulation functions; pointers and arrays. Structure and Class: Structure vs Classes, Objects, Member Variable, Member Function Constructors & Destructors and Inheritance: Role of Constructors & destructors, Types of Constructors, dynamic objects, Inheritance

Polymorphism: Types of Polymorphism, Early Binding vs Late Binding, Operator overloading, Function overloading, Function Overriding, Virtual functions, abstract class, virtual class.
Template, Exception and Files: Template functions & template classes, Exception handling, file stream classes, ASCII & Binary files, sequential & random access to a file.

Recommended Books:
1. HerbtzSchildt, "C++: The Complete Reference", Fourth Edition, McGraw Hill.2003
2. BjarneStroustrup, "The C++ Programming Language", 4th Edition, Addison-Wesley , 2013.
3. E Balaguruswamy, "Object Oriented Programming with C++", Tata McGraw-Hill Education, 2008.
4. John R. Hubbard, "Programming with C++", Schaum's Series, 2nd Edition, 2000.

<u>Minor Project Syllabus/Area</u>

Learning Objectives:
1. An interdisciplinary approach to complex environmental problems using basic tools of the natural and social sciences including geosystems, biology, chemistry, economics, political science and international processes.
2. An experience-based understanding of the human and natural environment of the world including water and energy needs, air quality, marine and coastal issues.

Learning Outcomes:
1. Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
2. Understand the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.
3. Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.
4. Understand key concepts from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.

Seminar, literature review/survey, relation between/among science, technology, society, religion, lifelong learning, lifelong education, group activities, social work, project, attending seminar/conference/workshop, philosophy of science/science of philosophy, sports, yoga, meditation, teaching, MOOC/e-learning, reading courses, technical club etc,, can be considered as extracurricular activity/activities,
Student(s) must take necessary permission form the instructor/Head, submit the progress report, give final presentation of his/her activity/activities, and submit the Final Report to the concerned instructor and the Department,
[NOTE: There will be no examination(s) of this paper,]

Ability Enhancement Compulsory Course (AECC)

<u>Environmental Science</u>

Course Objectives: To provide basic knowledge about the environment – ecosystems, resources, biodiversity, conservation, and factors affecting the environment (*i.e*., pollutants).

Learning Outcomes: After completion of the course the learners will have basic knowledge of environment, ecosystems, various types of energy sources, and factors affecting the environment. It will make students more responsible toward the environment. Students will be able to understand the importance of environment in our society.

Introduction to environmental studies

- Multidisciplinary nature of environmental studies;
- Scope and importance; Concept of sustainability and sustainable development,

Ecosystems

- What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession, Case studies of the following ecosystems :
  a) Forest ecosystem
  b) Grassland ecosystem
  c) Desert ecosystem
  d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Natural Resources: Renewable and Non--renewable Resources

- Land resources and land use change; Land degradation, soil erosion and desertification,
- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations,
- Water : Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter--state),
- Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies,

Biodiversity and Conservation

- Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots
- India as a mega-biodiversity nation; Endangered and endemic species of India
- Threats to biodiversity: Habitat loss, poaching of wildlife, man--wildlife conflicts, biological invasions; Conservation of biodiversity : In--situ and Ex--situ conservation of biodiversity,
- Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value,

Environmental Pollution

- Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution
- Nuclear hazards and human health risks
- Solid waste management: Control measures of urban and industrial waste,
- Pollution case studies,

Environmental Policies & Practices

- Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture

English Communication

Course Objectives: To develop essential soft skills for reading, writing, and communication purposes.

Learning Outcomes: After completion of the course the learners will be able to communicate, read, and write effectively in English.

Introduction
1, What is communication?
2, Types of communication: Horizontal, Vertical, Interpersonal, Grapevine,
3, Uses of Communication,

Language of Communication
1, Verbal: spoken and written
2, Non-verbal: Proxemics, Kinesics, Haptics, Chronemics, Paralinguistic
3, Barriers to communication

Reading Comprehension
1, Locate and remember the most important points in the reading,
2, Interpret and evaluate events, ideas, and information,
3, Read "between the lines" to understand underlying meanings,
4, Connect information to what they already know,

Writing
1, Expanding an Idea,
2, Note Making,
3, Memo,
4, Writing Formal Email,
5, Writing a Business Letter,
6, Report Writing,

Suggested Reading: Raman & Singh (Eds,)***, Business Communication*****,** 2nd Ed,, OUP, New Delhi

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