

**CURRICULUM
OF
BS PHYSICS**

(2026)



**RAWALPINDI WOMEN UNIVERSITY,
RAWALPINDI**

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1. Program Learning Outcomes

By the completion of Bachelor of Science in Physics, the graduates will be able to:

- a. Demonstrate a comprehensive understanding of basic concepts related to core physics, including but not limited to classical mechanics, quantum mechanics, electromagnetism, statistical mechanics and thermodynamics.
- b. Effectively apply mathematical and computational techniques to analyze and solve complex physical problems in both theoretical and experimental contexts.
- c. Communicate scientific knowledge and research findings effectively, demonstrating a commitment to continuous learning and professional development in the field of Physics.

2. Admission Criteria for BS Physics

As per approved Admission Policy RWU notified vide Notification No. RWU/VC/01/341; dated: 10th March 2023.

3. Division and Distribution of Courses for BS Physics

Categories	No. of Courses	Credit Hours
General Education Courses	13	32
Major Courses	28	78
Interdisciplinary / Allied Courses	06	18
Field Experience / Internship	01	03
Capstone Project	01	03
Mandatory Courses	02	02
HEC requirement BS Program	Min. 134 – Max. 144	
Current Total in BS Physics		136
Program Duration	Minimum: 4 years (8 regular semesters) Maximum: 6 years (12 regular semesters) The maximum limit is further extendable in accordance with HEC semester rules	
Semester Duration	16-18 weeks for regular semesters (1-2 weeks for examination) 8-9 weeks for summer semesters (1 week for examination)	
Course Load (per semester)	15-18 credit hours for regular semesters Up-to 8 credit hours for summer semesters (for remedial/deficiency/failure/repetition courses only)	
3 Credit Hours (Theory)	3 classes (1 hour each) OR 2 classes (1.5 hour each) OR 1 class (3 hours) per week throughout the semester	
1 Credit Hours (Lab / Field Work)	1 credit hour in laboratory or practical work / project requires lab contact of 3 hours per week throughout the semester	

Distribution of Credit Hours Within General Education Courses

No.	Course Code	Course Title	Course Type	Prereq	Cr. Hr.
1.	ENG-110	Functional English	General Education	Nil	3
2.	PAK-103	Ideology and Constitution of Pakistan	General Education	Nil	2
3.	MTH-110	Quantitative Reasoning-I	General Education	Nil	3
4.	SOC-104	Introduction to Social Sciences ²	General Education	Nil	2
5.	ENG-111	Expository Writing	General Education	Nil	3
6.	ISL-101/ ETH-101	Islamic Studies / Ethics	General Education	Nil	2
7.	PAK-104	Pakistan Studies	General Education	Nil	2
8.	STA-112	Quantitative Reasoning-II	General Education	Nil	3
9.	CS-107	Application of Information and Communication Technologies	General Education	Nil	2
10.	CS-107L	Application of Information and Communication Technologies (Lab)	General Education	Nil	1
11.	MGT-108	Entrepreneurship	General Education	Nil	2
12.	CCE-497	Civic and Community Engagement	General Education	Nil	2
13.	—	Natural Sciences ¹	General Education	Nil	3
14.	BFA-129	Arts and Humanities	General Education	Nil	2
Total General Education Cr Hrs:					32

¹To be chosen from the Pool of Natural Sciences category.

4. Scheme of Studies for BS Physics (Regular Batch)

Semester	Course Code	Course Title	Course Type	Prerequisites	Cr. Hr.
First	ENG-110	Functional English	General Education	Nil	3
	PAK-104	Pakistan Studies	General Education	Nil	2
	MTH-110	Quantitative Reasoning-I	General Education	Nil	3
	SOC-104	Introduction to Social Sciences	General Education	Nil	2
	PHY-126	Calculus-I	Major	Nil	3
	PHY-127	Introductory Mechanics	Major	Nil	2
	PHY-127L	Introductory Mechanics (Lab)	Major	Nil	1
	UHQ-101/ ETH-103	Understanding of Holy Quran-I/ Ethics-I	Mandatory	Nil	1
	Total (1st)				17
Second	ENG-111	Expository Writing	General Education	Nil	3
	ISL-101/ ETH-101	Islamic Studies / Ethics	General Education	Nil	2
	PAK-103	Ideology and Constitution of Pakistan	General Education	Nil	2
	STA-112	Quantitative Reasoning-II	General Education	Nil	3
	PHY-128	Calculus-II	Major	Nil	3
	PHY-129	Electricity and Magnetism	Major	Nil	2
	PHY-129L	Electricity and Magnetism (Lab)	Major	Nil	1
	UHQ-102/ETH-104	Understanding of Holy Quran-II/Ethics-II	Mandatory	Nil	1
	Total (2nd)				17
Third	CS-107	Application of Information and Communication Technologies	General Education	Nil	2
	CS-107L	Application of Information and Communication Technologies (Lab)	General Education	Nil	1
	MGT-108	Entrepreneurship	General Education	Nil	2
	CCE-497	Civic and Community Engagement	General Education	Nil	2
	PHY-207	Differential Equations	Major	Nil	3
		Natural Sciences*	General Education	Nil	3
	PHY-208	Waves and Optics	Major	Nil	2

	PHY-208L	Waves and Optics (Lab)	Major	Nil	1
	Total (3rd)				16
Fourth	MTH-111	Elementary Linear Algebra	Interdisciplinary/Allied	Nil	3
	BFA-129	Arts and Humanities	General Education	Nil	2
	PHY-210	Vector Calculus	Major	Nil	3
	PHY-211	Modern Physics	Major	Nil	2
	PHY-211L	Modern Physics (Lab)	Major	Nil	1
	PHY-212	Heat and Thermodynamics	Major	Nil	2
	PHY-212L	Heat and Thermodynamics (Lab)	Major	Nil	1
	PHY-305	Classical Mechanics	Major	Nil	3
	Total (4th)				17
Fifth	PHY-319	Electromagnetic Theory	Major	Nil	3
	PHY-302	Mathematical Methods of Physics-I	Major	Nil	3
	PHY-321	Environmental Physics	Interdisciplinary/Allied	Nil	3
	PHY-322	Scientific Inquiry and Research Methods	Interdisciplinary/Allied	Nil	3
	PHY-323	Electronics-I	Major	Nil	2
	PHY-323L	Electronics-I (Lab)	Major	Nil	1
	Total (5th)				15
Sixth	PHY-324	Electrodynamics and Special Relativity	Major	Nil	3
	PHY-308	Mathematical Methods of Physics-II	Major	PHY-302	3
	PHY-303	Quantum Mechanics-I	Major	Nil	3
	PHY-325	Condensed Matter Physics	Major	Nil	3
	PHY-326	Electronics-II	Major	Nil	2
	PHY-326L	Electronics-II (Lab)	Major	Nil	1
	PHY-327	Computational Physics	Interdisciplinary/Allied	Nil	2
	PHY-327L	Computational Physics (Lab)	Interdisciplinary/Allied	Nil	1
	Total (6th)				18
Seventh	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY-427	Atomic and Molecular Physics	Major	Nil	2

	PHY-427L	Atomic and Molecular Physics (Lab)	Major	Nil	1
	PHY-309	Quantum Mechanics-II	Major	PHY-303	3
	PHY-428	Nuclear Physics	Major	Nil	2
	PHY-428L	Nuclear Physics (Lab)	Major	Nil	1
	INT-499	Internship	Mandatory	Nil	3
	Total (7th)				18
Eighth	CP-498	Capstone Project	Mandatory	Nil	3
	PHY-429	Statistical Mechanics	Major	Nil	3
	PHY-430	Artificial Intelligence in Physics	Interdisciplinary/Allied	Nil	2
	PHY-430L	Artificial Intelligence in Physics (Lab)	Interdisciplinary/Allied	Nil	1
	PHY-410	Medical Physics	Interdisciplinary/Allied	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
Total (8th)					18
Total Credit Hours:					136

*To be chosen from the list of Natural Sciences category.

**To be chosen from the Pool of Field Specific Major Courses in Physics.

5. Scheme of Studies for BS Physics (BSc with 50 Cr. Hrs.)

Semester	Course Code	Course Title	Category	Prereq	Cr Hrs
Fifth	PHY-319	Electromagnetic Theory	Major	Nil	3
	PHY-302	Mathematical Methods of Physics-I	Major	Nil	3
	PHY-321	Environmental Physics	Interdisciplinary /Allied	Nil	3
	PHY-322	Scientific Inquiry and Research Methods	Interdisciplinary /Allied	Nil	3
	PHY-323	Electronics-I	Major	Nil	2
	PHY-323L	Electronics-I (Lab)	Major	Nil	1
	ENG-110	Functional English	General Education	Nil	3
	PHY-127	Introductory Mechanics	Major	Nil	2
	PHY-127L	Introductory Mechanics (Lab)	Major	Nil	1
	Total (5th)				21
Sixth	PHY-324	Electrodynamics and Special Relativity	Major	Nil	3
	PHY-308	Mathematical Methods of Physics-II	Major	PHY-302	3
	PHY-303	Quantum Mechanics-I	Major	Nil	3
	PHY-325	Condensed Matter Physics	Major	Nil	3
	PHY-326	Electronics-II	Major	Nil	2
	PHY-326L	Electronics-II (Lab)	Major	Nil	1
	PHY-327	Computational Physics	Interdisciplinary /Allied	Nil	2
	PHY-327L	Computational Physics (Lab)	Interdisciplinary /Allied	Nil	1
	PHY-129	Electricity and Magnetism	Major	Nil	2
	PHY-129L	Electricity and Magnetism (Lab)	Major	Nil	1
	Total (6th)				21
Summer	INT-499	Internship	Mandatory	Nil	3
	Total Summer				3
Seventh	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY-427	Atomic and Molecular Physics	Major	Nil	2

	PHY-427L	Atomic and Molecular Physics (Lab)	Major	Nil	1
	PHY-309	Quantum Mechanics-II	Major	PHY-303	3
	PHY-428	Nuclear Physics	Major	Nil	2
	PHY-428L	Nuclear Physics (Lab)	Major	Nil	1
	PHY-208	Waves and Optics	Major	Nil	2
		Natural Sciences	General Education	Nil	3
	Total (7th)				20
Eighth	CP-498	Capstone Project	Mandatory	Nil	3
	PHY-429	Statistical Mechanics	Major	Nil	3
	PHY-430	Artificial Intelligence in Physics	Interdisciplinary /Allied	Nil	2
	PHY-430L	Artificial Intelligence in Physics (Lab)	Interdisciplinary /Allied	Nil	1
	PHY-410	Medical Physics	Interdisciplinary /Allied	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	MTH-111	Elementary Linear Algebra	Interdisciplinary /Allied	Nil	3
	Total (8th)				21
	Total Credit Hours				86
	Credit Hours from the Previous Degree				50
	Grand Total				136

**To be chosen from the Pool of Field Specific Major Courses in Physics.

6. Scheme of Studies for BS Physics (Lateral Entry 65 Cr Hrs)

Semester	Course Code	Course Title	Category	Prereq	Cr. Hrs.
Fifth	PHY-319	Electromagnetic Theory	Major	Nil	3
	PHY-302	Mathematical Methods of Physics-I	Major	Nil	3
	PHY-321	Environmental Physics	Interdisciplinary/ Allied	Nil	3
	PHY-322	Scientific Inquiry and Research Methods	Interdisciplinary/ Allied	Nil	3
	PHY-323	Electronics-I	Major	Nil	2
	PHY-323L	Electronics-I (Lab)	Major	Nil	1
	Total (5th)				15
Sixth	PHY-324	Electrodynamics and Special Relativity	Major	Nil	3
	PHY-308	Mathematical Methods of Physics-II	Major	PHY-302	3
	PHY-303	Quantum Mechanics-I	Major	Nil	3
	PHY-325	Condensed Matter Physics	Major	Nil	3
	PHY-326	Electronics-II	Major	Nil	2
	PHY-326L	Electronics-II (Lab)	Major	Nil	1
	PHY-327	Computational Physics	Interdisciplinary/ Allied	Nil	2
	PHY-327L	Computational Physics (Lab)	Interdisciplinary/ Allied	Nil	1
	Total (6th)				18
Seventh	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY-427	Atomic and Molecular Physics	Major	Nil	2
	PHY-427L	Atomic and Molecular Physics (Lab)	Major	Nil	1
	PHY-309	Quantum Mechanics-II	Major	PHY-303	3
	PHY-428	Nuclear Physics	Major	Nil	2
	PHY-428L	Nuclear Physics (Lab)	Major	Nil	1
	CCE-497	Civic and Community Engagement	General Education	Nil	2
	INT-499	Internship	Mandatory	Nil	3
	Total (7th)				20
Eighth	CP-498	Capstone Project	Mandatory	Nil	3
	PHY-429	Statistical Mechanics	Major	Nil	3
	PHY-430	Artificial Intelligence in Physics	Interdisciplinary/ Allied	Nil	2

	PHY-430L	Artificial Intelligence in Physics (Lab)	Interdisciplinary/ Allied	Nil	1
	PHY-410	Medical Physics	Interdisciplinary/ Allied	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	Total (8 th)				
Total Credit Hours:					71
Credit Hours from Previous Degree					65
Grand Total of Credit Hours					136

***To be chosen from the List of Field Specific Major Courses in Physics.

7. List of Major Courses

Semester	Course Code	Course Title	Course Type	Prereq	Cr. Hr.
First	PHY-126	Calculus-I	Major	Nil	3
	PHY-127	Introductory Mechanics	Major	Nil	2
	PHY-127L	Introductory Mechanics (Lab)	Major	Nil	1
Second	PHY-128	Calculus-II	Major	Nil	3
	PHY-129	Electricity and Magnetism	Major	Nil	2
	PHY-129L	Electricity and Magnetism (Lab)	Major	Nil	1
Third	PHY-207	Differential Equations	Major	Nil	3
	PHY-208	Waves and Optics	Major	Nil	2
	PHY-208L	Waves and Optics (Lab)	Major	Nil	1
Fourth	PHY-210	Vector Calculus	Major	Nil	3
	PHY-211	Modern Physics	Major	Nil	2
	PHY-211L	Modern Physics (Lab)	Major	Nil	1
	PHY-212	Heat and Thermodynamics	Major	Nil	2
	PHY-212L	Heat and Thermodynamics (Lab)	Major	Nil	1
	PHY-305	Classical Mechanics	Major	Nil	3
Fifth	PHY-302	Mathematical Methods of Physics-I	Major	Nil	3
	PHY-319	Electromagnetic Theory	Major	Nil	3
	PHY-323	Electronics-I	Major	Nil	2
	PHY-323L	Electronics-I (Lab)	Major	Nil	1
Sixth	PHY-324	Electrodynamics and Special Relativity	Major	Nil	3
	PHY-308	Mathematical Methods of Physics-II	Major	PHY-302	3
	PHY-303	Quantum Mechanics-I	Major	Nil	3
	PHY-325	Condensed Matter Physics	Major	Nil	3
	PHY-326	Electronics-II	Major	Nil	2
	PHY-326L	Electronics-II (Lab)	Major	Nil	1
Seventh	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY-427	Atomic and Molecular Physics	Major	Nil	2
	PHY-427L	Atomic and Molecular Physics (Lab)	Major	Nil	1
	PHY-309	Quantum Mechanics-II	Major	PHY-303	3
	PHY-428	Nuclear Physics	Major	Nil	2
	PHY-428L	Nuclear Physics (Lab)	Major	Nil	1
Eighth	PHY-429	Statistical Mechanics	Major	Nil	3

	PHY----	Field Specific Major Course**	Major	Nil	3
	PHY----	Field Specific Major Course**	Major	Nil	3
Total Major:					78

**To be chosen from the Pool of Field Specific Major Courses in Physics.

8. Course Outlines for Major Courses

Calculus-I

BS-Physics

Course Code: PHY-126

Credit Hours: 03

Prerequisites: Nil

Objectives

This course is designed to develop students' understanding of fundamental concepts in calculus, focusing on limits, continuity, and derivatives. It aims to enable students to apply differentiation techniques to real-world physical problems and perform basic integration of elementary functions for computing areas and volumes

Learning Outcomes

- Solve problems involving limits, continuity, and derivatives of functions.
- Apply differentiation techniques to analyze real-world physical scenarios.
- Integrate elementary functions and apply them to computing areas and volumes.

Course Outline

Unit 1. Preliminaries of Mathematics

Order of operations (PEMDAS), properties of real numbers, laws of exponents and radicals, operations with fractions and decimals. Coordinate plane and graphing basics. Introduction to scientific notation and significant figures. Basics of mathematical notation, use of symbols, and interpreting word problems into mathematical form. Concept of variables, constants, and basic equation solving techniques.

Unit 2. Fundamentals of Mathematics

Basic number operations, algebraic expressions, introduction to functions, types of functions (linear, quadratic, polynomial, rational, exponential, logarithmic), domain and range, composition and inverse of functions.

Unit 3. Limits and Continuity

Definition of limits, limit laws, methods for evaluating limits, one-sided limits, continuity of functions, types of discontinuities, Intermediate Value Theorem.

Unit 4. Differentiation

The concept of the derivative, graphical interpretation, basic differentiation rules (power rule, product rule, quotient rule, chain rule), derivatives of trigonometric, exponential, and logarithmic functions, higher-order derivatives.

Unit 5. Applications of Differentiation

Tangents and normals, related rates, optimization problems, curve sketching using first and second derivative tests, concavity, inflection points.

Unit 6. Introduction to Integration

Antiderivatives, basic integration rules, indefinite integrals, definite integrals, Fundamental Theorem of Calculus.

Recommended Books/Reference Material

1. Anton, H. Bivens, I.C., and Davis, S. (2021). *Calculus*. John Wiley and Sons.
2. Ayres, F., and Mendelson, E. (2009). *Calculus*. Schaum's Outlines.
3. Hughes-Hallett, D., Gleason, A.M., and McCallum, W.G. (2020). *Calculus: Single and Multivariable*. John Wiley and Sons.
4. Stewart, J., Clegg, D.K., and Watson, S. (2020). *Calculus: Early Transcendentals*. Cengage Learning.
5. Thomas, G. B., Finney, R. L., Weir, M. D., & Giordano, F. R. (2003). *Thomas' calculus*. Reading: Addison-Wesley.

Calculus-II

BS-Physics

Course Code: PHY-128

Credit Hours: 03

Prerequisite: Nil

Objectives

This course is designed to enhance students' proficiency in integral calculus and introduce them to advanced mathematical tools essential for physics. It aims to develop the ability to solve integrals involving trigonometric, exponential, and logarithmic functions, analyze the convergence of sequences and series, and apply multivariable calculus techniques to model and solve problems in physical contexts.

Learning Outcomes

- Solve integrals involving trigonometric, exponential, and logarithmic functions.
- Analyze sequences and series for convergence.
- Apply multivariable calculus to solve problems in physics.

Course Outline

Unit 1. Techniques of Integration

Integration by substitution, integration by parts, partial fraction decomposition, trigonometric integrals, improper integrals.

Unit 2. Applications of Integration

Area under curves, area between curves, volume of solids of revolution (disk and shell methods), arc length, surface area of revolution, physical applications.

Unit 3. Sequences and Series

Definition and properties of sequences, limits of sequences, infinite series, convergence tests, power series, Taylor and Maclaurin series, radius and interval of convergence.

Unit 4. Parametric Equations and Polar Coordinates

Parametric equations, derivatives of parametric functions, arc length and surface area in parametric form, polar coordinates, graphing polar curves, calculus in polar coordinates.

Unit 5. Introduction to Differential Equations

Basic concepts and classifications of differential equations, first-order separable and linear differential equations, applications in population growth, decay, and motion.

Recommended Books/Reference Material

1. Anton, H., Bivens, I. C., Davis, S. (2022). *Calculus: Single Variable*. United States: Wiley.
2. Fehribach, J. D. (2023). *Sequences and Series in Calculus*. Germany: De Gruyter.
3. HughesHallett, D., Gleason, A. M., McCallum, W. G. (2020). *Calculus: Single and Multivariable*. United Kingdom: Wiley.
4. Stewart, J., Clegg, D.K., and Watson, S. (2020). *Calculus: Early Transcendentals*. Cengage Learning.

5. Thomas, G. B., Finney, R. L., Weir, M. D., & Giordano, F. R. (2003). *Thomas' calculus*. Reading: Addison-Wesley.

Introductory Mechanics

BS-Physics

Course Code: PHY-127

Credit Hours: 02

Prerequisites: Nil

Objectives

This course is designed to introduce students to the foundational principles of mechanics, focusing on the motion of particles and systems under the influence of forces. Students will develop a strong conceptual understanding of Newtonian mechanics, as well as the ability to analyze mechanical systems using the principles of force, momentum, and energy conservation.

Learning Outcomes

- Apply the basic principles of mechanics to solve problems involving motion.
- Analyze the dynamics of systems under the influence of forces.
- Describe the conservation of momentum and energy in mechanical systems.

Course Outline

Unit 1. Kinematics in One and Two Dimensions

Displacement, velocity, and acceleration. Equations of motion for constant acceleration. Projectile motion and uniform circular motion.

Unit 2. Newton's Laws of Motion

Concepts of force and mass. Newton's three laws and their applications to particle motion. Frictional forces and tension.

Unit 3. Work and Energy

Work done by a force. Kinetic and potential energy. Work-energy theorem. Conservative and non-conservative forces.

Unit 4. Momentum and Impulse

Linear momentum, impulse-momentum theorem, conservation of linear momentum. Elastic and inelastic collisions in one and two dimensions.

Unit 5. Rotation and Angular Momentum

Rotational motion of rigid bodies, angular velocity and angular acceleration, rotational kinematics. Torque and moment of inertia, Newton's second law for rotation. Rotational kinetic energy and work-energy theorem in rotational systems. Angular momentum, conservation of angular momentum, and applications.

Recommended Books/Reference Material

1. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
2. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics* (12th ed.). John Wiley.
3. Kleppner, D., & Kolenkow, R. (2013). *An Introduction to Mechanics*. Cambridge University Press.

4. Serway, R. A., & Jewett, J. W. (2018). *Physics for Scientists and Engineers* (10th ed.). Cengage Learning.
5. Young, H. D., & Freedman, R. A. (2019). *University Physics with Modern Physics* (15th ed.). Addison-Wesley.

Introductory Mechanics (Lab)

BS-Physics

Course Code: PHY-127L

Credit Hours: 01

Prerequisites: Nil

Objectives

This lab course provides hands-on experience in applying the core concepts of mechanics. Students will experimentally verify principles of motion, force, energy, and momentum, and develop skills in data collection, analysis, and scientific reporting.

Learning Outcomes:

- Apply the basic principles of mechanics to solve problems involving motion through experiments.
- Analyze the dynamics of systems under the influence of forces using experimental methods.
- Demonstrate the conservation of momentum and energy in laboratory-based mechanical systems.

List of Experiments:

1. Experimentally determine the acceleration due to gravity (g) by timing the free fall of an object from a known height using a photo-gate timer or a simple pendulum.
2. Investigate the relationship between the force applied to an object and its resulting acceleration using a dynamics cart on an inclined plane or a mass on a frictionless surface.
3. Explore the conservation of momentum by colliding two objects on an air track or a table with low-friction surfaces. Examine elastic and inelastic collisions.
4. Study SHM by analyzing the motion of a simple pendulum or a mass-spring system. Determine factors affecting the period and amplitude of oscillation.
5. Investigate the relationship between centripetal force, mass, and radius of rotation using a rotating platform or a conical pendulum.
6. Determine the coefficient of friction between different surfaces using an inclined plane and a variety of objects. Analyze static and kinetic friction.
7. Study the concept of work and energy conservation by lifting weights to various heights and calculating the work done and potential energy gained.
8. Analyze the trajectory of a projectile by launching objects at different angles and velocities, and calculate the range, maximum height, and time of flight.
9. Explore the principles of rotational motion using rotating wheels or disks. Investigate angular velocity, moment of inertia, and angular acceleration.
10. Experiment with objects in rotational equilibrium and determine the torque needed to maintain equilibrium. Use a meter stick or a balance beam.
11. Verify Hooke's Law by applying different forces to a spring and measuring the resulting elongation or compression.
12. Investigate how the period of a simple pendulum changes with different lengths and compare your results to theoretical predictions.
13. Study rolling motion by releasing objects down an incline and measuring their acceleration. Compare the results to theoretical predictions for pure rolling.

14. Determine the coefficient of restitution by dropping a ball onto a hard surface and measuring the rebound height.
15. Explore the conservation of angular momentum using a rotating chair and observe changes in rotational speed when the chair's arms are extended or brought closer.

Recommended Books/Reference Material

1. Fornasini P. (2008). *The Uncertainty in Physical Measurements : An Introduction to data analysis in the physics laboratory*. Springer.
2. Kraftmakher I. A. A. (2015). *Experiments and demonstrations in physics: Bar-ilan physics laboratory* (2nd ed.). World Scientific.
3. Loyd, D. H. (2008). *Physics Laboratory Manual*. Thomson Higher Education.
4. Smith W. F. (2020). *Experimental Physics : Principles and Practice for the Laboratory*. CRC Press Taylor & Francis Group.
5. Smith, W. F. (2020). *Experimental Physics: Principles and Practice for the Laboratory*. Taylor and Francis.
6. Wilson, J. D., & Hernández-Hall, C. A. (2014). *Physics Laboratory Experiments*. Cengage Learning.

Electricity and Magnetism

BS-Physics

Course Code: PHY-129

Credit Hours: 02

Prerequisites: Nil

Objectives

The primary focus of this course is to provide a basic understanding of electric and magnetic fields. The course will impart basic skills to enable students to apply the principles and concepts of electricity and magnetism in practical situations.

Learning Outcomes

- Apply electrostatics and magnetostatics to solve various problems.
- Explain fundamental laws in electricity and magnetism especially with regards to Maxwell's Law.
- Describe the interaction between charged particles and electromagnetic fields.

Course Outline

Unit 1. Electric Charge and Field

Electric charge, coulombs law, Electric field, continuous charge distributions, image charges, electric dipole, Gauss's Law and its applications, electric potential, electric properties of materials, capacitor, dielectric, capacitors in circuits, energy stored in capacitors, electric polarization, Gauss's Law for dielectrics,

Unit 2. Current and Electric Circuits

Electric current, current density and Ohm's law, equation of continuity, DC circuits, analysis of circuits, Electric fields in circuits, resistance in circuits, energy transfers in a circuit, RC circuits.

Unit 3. Magnetic Field and its Applications

magnetism, magnetic force on a charged particle, magnetic torque due to currents, magnetic dipole, Biot-Savart Law and its applications, Ampere's law and its applications, Gauss' law for magnetism, origin of atomic and nuclear magnetism, magnetization, magnetic materials: diamagnetic, paramagnetic, ferromagnetic.

Unit 4. Induction and Its Applications

Induced magnetic fields and displacement current. Faraday's Law of electromagnetic induction, review of emf, Lenz's Law, Induced electric fields, Inductance, Inductance of a Solenoid and Toroid. Transients, LR Circuits, Growth and Decay of current, Energy stored in a magnetic field, Energy density, Electromagnetic Oscillation, Qualitative and Quantitative analysis, Forced electromagnetic oscillations and resonance.

Unit 5. Alternating Current

Alternating current, AC current in resistive, inductive and capacitive elements, single loop RLC circuit, acceptor and rejecter circuits, Power in A.C circuits, Summarizing the electromagnetic equations, Induced magnetic fields & displacement current.

Recommended Books/Reference Material

1. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
2. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics* (12th ed.). John Wiley.

3. Kleppner, D., & Kolenkow, R. (2013). *An Introduction to Mechanics*. Cambridge University Press.
4. Serway, R. A., & Jewett, J. W. (2018). *Physics for Scientists and Engineers* (10th ed.). Cengage Learning.
5. Young, H. D., & Freedman, R. A. (2019). *University Physics with Modern Physics* (15th ed.). Addison-Wesley.

Electricity and Magnetism (Lab)

BS-Physics

Course Code: PHY- 129L

Credit Hours: 01

Prerequisites: Nil

Objectives

To understand working principles of electric components and electricity measurements instruments.

Learning Outcomes

- Understand the principles of electricity and magnetism through hands-on laboratory experiments.
- Demonstrate proficiency in using laboratory equipment for measuring electrical and magnetic quantities.
- Apply acquired knowledge to solve practical problems in electrical circuits and magnetic fields.

Course Outline

1. Determination of high resistance using neon flash lamp.
2. Study of resonance frequency of Acceptor circuit.
3. Study of resonance frequency of Rejecter circuit.
4. Measurement of self-inductance.
5. Measurement of mutual inductance.
6. Determination of current sensitivity of Ballistic galvanometer.
7. Charging and discharging of capacitor.
8. To determine dielectric constant of different materials using RLC series circuit.
9. Magnetic forces on a wire.
10. Magnetic fields of coils.
11. Faraday's law of induction.
12. Coulomb's law.
13. Electric Fields and Potentials in parallel plate capacitors.
14. Measurement of resistivity of different material.
15. Magnetic field of a single coil Biot-Savart's Law with Tesla meter.

Recommended Books/Reference Material

1. Castoldi, K. C. (2017). *General physics laboratory I experiments*. Kendall Hunt.
2. French, M. (2016). *Physics lab experiments*. Mercury Learning & Information.
3. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics* (12th ed.). John Wiley.
4. Hecht E. (2021). *College physics*. McGraw Hill Education.
5. Knight R. (2022). *Physics for scientists and engineers* (5th ed.). Pearson Education Limited.
6. Purcell, E. M., & Morin, D. J. (2013). *Electricity and magnetism* (3rd ed.). Cambridge.

Differential Equations

BS-Physics

Course Code: PHY-207

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will develop an understanding of ordinary and partial differential equations and their role in modeling physical systems. Emphasis will be placed on solution techniques, qualitative analysis, and applications in physics.

Learning Outcomes

- Solve ordinary differential equations (ODEs) relevant to physical systems.
- Analyze systems of differential equations in modeling physical phenomena.
- Apply partial differential equations (PDEs) to problems in physics.

Course Outline

Unit 1. First-Order Ordinary Differential Equations

Definition and classification of differential equations, separable and linear equations, exact equations, integrating factors, homogeneous and Bernoulli equations, physical applications: radioactive decay, Newton's law of cooling, population dynamics.

Unit 2. Higher-Order Linear ODEs

Second and higher-order linear ODEs with constant coefficients, method of undetermined coefficients, variation of parameters, reduction of order, applications: harmonic oscillator, LRC circuits, mechanical vibrations.

Unit 3. Systems of Differential Equations

Systems of first-order linear ODEs, matrix methods, eigenvalues and eigenvectors, phase plane analysis, physical applications: coupled oscillators, interacting populations, electrical circuits.

Unit 4. Series Solutions and Special Functions

Series solutions near ordinary points, Frobenius method, Bessel's and Legendre's equations, introduction to special functions, applications in wave equations and boundary value problems.

Unit 5. Introduction to Partial Differential Equations (PDEs)

Formation and classification of PDEs, solution of first-order PDEs, separation of variables, heat equation, wave equation, and Laplace's equation in one and two dimensions. Applications in heat flow, vibrating strings, and electrostatics.

Recommended Books/Reference Material

1. Boyce, W. E., & DiPrima, R. C. (2020). *Elementary Differential Equations and Boundary Value Problems* (11th ed.). Wiley.
2. Kreyszig, E. (2021). *Advanced Engineering Mathematics* (10th ed.). Wiley.
3. Zill, D. G. (2018). *A First Course in Differential Equations with Modeling Applications* (11th ed.). Cengage.
4. Simmons, G. F. (2023). *Differential Equations with Applications and Historical Notes* (4th ed.). McGraw-Hill.

5. Haberman, R. (2022). *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems* (6th ed.). Pearson.

Waves and Optics

BS-Physics

Course Code: PHY-208

Credit Hours: 02

Prerequisites: Nil

Objectives

This course aims to develop students' understanding of the mathematical theory underlying oscillations and waves in physical systems with practical approach, equipping them with the tools to analyze and comprehend dynamic phenomena in diverse scientific and engineering contexts.

Learning Outcomes

- Analyze the propagation of mechanical and electromagnetic waves.
- Apply the principles of interference, diffraction, and polarization to optical systems.
- Solve problems involving wave behavior in various media.

Course Outline

Unit 1. Simple Harmonic Motion

Simple Harmonic Motion (SHM), its types and applications, Energy consideration in SHM, SHM & uniform circular motion, combinations of Harmonic motion.

Unit 2. Waves

Sinusoidal waves, wave equation. Phase velocity and group velocity, dispersion, power and intensity in wave motion transverse standing waves normal modes. Longitudinal standing and longitudinal travelling waves.

Unit 3. Damped and Forced Oscillations

Damped harmonic motion, Forced Oscillation & Resonance, Traveling waves, wave speed, Power & intensity in wave motion. LCR circuit, driven LCR circuit

Unit 4. Superposition principle

Principle of superposition, standing waves, Interference of waves, Beats, Doppler effect, visible light , speed of light in matter, double slit interference, intensity in Double slit interference, adding waves using phase vector, interference from thin film, Single slit diffraction, Intensity in single slit diffraction using phasors, diffraction at circular aperture, diffraction grating, x-ray Diffraction, Polarization.

Unit 5. Optics

Geometrical optics and its laws, Optical Instruments including simple Magnifiers, Telescopes and Microscopes, Michelson interferometer, Newton's rings, Polarization by Reflection, & Double Refraction, Polarization states, Rotation of Plane Polarization, Basics of fiber optics.

Recommended Books/Reference Material

1. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics* (Extended) (12th ed.). Wiley Publishing.
2. Hecht, E. (2017). *Optics* (6th ed.). Addison Wesley.
3. Hecht, E., & Ganesan, A. (2008). *Optics* (4th ed.). Dorling Kindersley.
4. Pedrotti, F., Pedrotti, L. S., & Pedrotti, L. M. (2018). *Introduction to optics* (3rd ed.). Pearson, Addison Wesley.
5. Sharam, K. K. (2006). *Optics: principles and applications*. Academic Press.
6. Thorne K. S. & Blandford R. D. (2021). *Optics*. Princeton University Press.

Waves and Optics (Lab)

BS-Physics

Course Code: PHY-208L

Credit Hours: 01

Prerequisites: Nil

Objectives

To develop the understanding of students in measuring the waves and optical parameters.

Learning Outcomes

- To experimentally analyze the propagation characteristics of mechanical and electromagnetic waves.
- To investigate the phenomena of interference, diffraction, and polarization through laboratory experiments.
- To apply measurement techniques to study wave behavior in different physical media.
- To develop data analysis and interpretation skills related to experimental wave phenomena.

Course Outline

1. To study parameters of waves by CRO. (Wavelength, amplitude, time period).
2. Investigate wave interference and the formation of interference patterns on the surface of water using a ripple tank. Explore concepts of constructive and destructive interference.
3. Determination of frequency of AC supply by CRO (Lissajous figures).
4. Investigate phase study electrical resonance in an LCR (inductor, capacitor, and resistor) circuit.
5. Determine the resonant frequency and analyze the behavior of the circuit at resonance.
6. Difference between two coherent sources using a Michelson interferometer or a Lloyd's mirror setup.
7. Observe and analyze interference patterns of waves using a double-slit apparatus with various wavelengths and separations.
8. To find number of lines per centimeter of a given grating.
9. Michelson's interferometer. To determine wavelength of sodium light by diffraction grating.
10. To determine the power of diffraction grating.
11. To determine wavelength of sodium light by Newton's Ring.
12. To determine the height of an object by sextant.

Recommended Books/Reference Material

1. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics* (Extended) (12th ed.). Wiley Publishing.
2. Hecht, E. (2017). *Optics* (6th ed.). Addison Wesley.
3. J. D. Wilson, (2024). *Physics laboratory experiments*, Cengage Publishing, USA.
4. Pedrotti, F., Pedrotti, L. S., & Pedrotti, L. M. (2018). *Introduction to optics* (3rd ed.). Pearson, Addison Wesley.
5. Thorne K. S. & Blandford R. D. (2021). *Optics*. Princeton University Press.

Modern Physics

BS-Physics

Course Code: PHY-211

Credit Hours: 02

Prerequisite: Nil

Objectives

This course introduces essential concepts in modern physics, emphasizing basics of quantum physics, relativity, and particle physics. Students will gain problem-solving skills and apply these principles to explain phenomena in various scientific and technological contexts.

Learning Outcomes

- Describe the basic concepts of quantum mechanics and relativity.
- Apply quantum mechanical principles to atomic and subatomic systems.
- Analyze the experimental basis and implications of modern physics theories.

Course Outline

Unit 1. Introduction To Special Theory Of Relativity

Inertial and non-inertial frames of reference, Postulates of relativity, space and time, Lorentz transformation, time dilation, length contraction, twin Paradox, Relativistic momentum, and Relativistic energy.

Unit 2. Classical Physics and It's Failure

Black body radiation, Discussion, Comparison of Wein's, Rayleigh- Jeans & Planck's radiation formulae, Proof of Planck's radiation formula, Failure of classical wave theory.

Unit 3. Quantum Physics and Particle Aspect of Radiation

Quantization of energy, Photo-electric effect and its experimental results, Einstein photon theory, Calculation of Planck's constant from photo-electric equation, Compton effect, Experimental study and explanation on the basis of quantum theory.

Unit 4. Wave Aspect of Particle and Wave- particle Duality

Wave behavior of particle, De-Broglie hypothesis and its experimental verification, Wave packets and particles, Phase and group velocities, Localizing a wave in space and time, Heisenberg uncertainty principle, The correspondence principle, Complementarity principle, Wave-particle duality. Concept of wave function and probability density.

Unit 5. Atomic Physics

Bohr's postulates and Bohr's theory of H-atom, limitation of Bohr's theory, interpretation of Bohr's quantization rule, excitation and ionization energy, Bohr's theory of critical potential, Frank-Hertz experiment, angular momentum of electron, space quantization, electron spin, Stern & Gerlach experiment. Vector atom model. Orbital angular momentum, X-rays, production of X-rays, continuous and discrete x-ray spectrum, Moseley's law, Pauli Exclusion Principle.

Recommended Books/Reference Material

1. Beiser, A. (2022). *Concepts of modern physics* (6th ed.). McGraw-Hill.
2. Felder G. & Felder K. (2023). *Modern physics*. Cambridge University Press.
3. Giancoli, D. C. (2018). *Physics for scientists and engineers with modern physics* (4th ed.). Addison-Wesley.
4. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics (Extended)* (11th ed.). Wiley Publishing.

5. Serway, R. A., & Jewett, J. W. (2019). *Physics for scientists and engineers* (10th ed.). Golden Sunburst Series.
6. Weinberg S. (2021). *Foundations of modern physics*. Cambridge University Press.
7. Young, H. D., & Freedman, R. A. (2019). *University physics* (15th ed.). Addison-Wesley.

Modern Physics (Lab)

BS-Physics

Course Code: PHY-211L

Credit Hours: 01

Prerequisite: Nil

Objectives

The Modern Physics Lab is designed to provide students with the opportunity to demonstrate some of the basic ideas of modern and quantum physics.

Learning Outcomes

- Students will be able to apply their skills in accurately determining fundamental constants, such as the Planck's constant, and showcasing their analytical prowess in the realm of experimental physics.
- Students will not only develop practical skills but also expand their understanding of modern physics principles.

Course Outline

1. Determination of the specific charge of the electron with the help of fine beam tube, Helmholtz coils with holder.
2. Determining Planck's constant (selection of wavelengths with interference filters on the optical bench).
3. Millikan's oil drop experiment (demonstration of the quantization of charge).
4. I-V characteristics and efficiency measurement of solar cell.
5. Determination of ionization potential of mercury.
6. Determination of speed of light.
7. To study Hall effect in metals.
8. To determine the variation of photoelectric current with the change of intensity of light.
9. To verify the Stefan Boltzmann Law
10. Determining excitation potential of Ne between 2s to 3p states using a Frank-Hertz setup.

Recommended books/reference material

1. Ghosh, S. K. (2021). *A textbook of advanced practical physics*. New Central Book Agency.
2. Melissinos, A. C., & Napolitano, J. (2019). *Experiments in modern physics* (2nd ed.). Academic Press.
3. Price, C. B., & Price-Mohr, R. (2020). *Physlab: A 3D virtual physics laboratory of simulated experiments for advanced physics learning*. Physics Education.
4. Smith, W. F. (2020). *Experimental physics: Principles and practice for the laboratory*. CRC Press Taylor & Francis Group.
5. Squires, G. L. (2023). *Practical physics* (4th ed.). Cambridge University Press.

Vector Calculus

BS-Physics

Course Code: PHY-210

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will develop the ability to apply vector calculus techniques to physical problems, particularly in mechanics and electromagnetism. The course will provide fundamental knowledge of vector differentiation, vector integration, and the theorems of vector calculus.

Learning Outcomes

- Apply vector calculus to solve problems in mechanics and electromagnetism.
- Analyze the behavior of vector fields using gradient, divergence, and curl.
- Use vector integrals to solve physical problems involving line, surface, and volume integrals.

Course Outline

Unit 1. Vector Algebra and Functions

Vectors and scalars, vector addition and subtraction, dot product, cross product, scalar and vector triple products, vector functions, limits, continuity, and differentiation of vectors.

Unit 2. Vector Differentiation

Gradient of a scalar field and its physical significance, directional derivatives. Divergence and curl of vector fields, physical interpretations, conservative fields, and potential functions. Applications in mechanics and electromagnetism.

Unit 3. Line Integrals and Application

Definition and computation of line integrals, work done by a force field, conservative vector fields and path independence, applications in mechanics and electromagnetism.

Unit 4. Surface and Volume Integrals

Definition and computation of surface integrals, flux of a vector field, volume integrals and their applications in physics. Applications in fluid dynamics and electromagnetism.

Unit 5. Theorems of Vector Calculus

Green's theorem, Gauss's divergence theorem, Stokes' theorem, physical interpretations, and applications in mechanics, electromagnetism, and fluid dynamics.

Recommended Books/Reference Material

1. Arfken, G. B., & Weber, H. J. (2023). *Mathematical Methods for Physicists* (7th ed.). Academic Press.
2. Griffiths, D. J. (2023). *Introduction to Electrodynamics* (5th ed.). Cambridge University Press.
3. Marsden, J. E., & Tromba, A. J. (2021). *Vector Calculus* (6th ed.). W. H. Freeman.
4. Riley, K. F., Hobson, M. P., & Bence, S. J. (2018). *Mathematical Methods for Physics and Engineering* (4th ed.). Cambridge University Press.
5. Schey, H. M. (2020). *Div, Grad, Curl, and All That: An Informal Text on Vector Calculus* (4th ed.). W. W. Norton & Company.
6. Spiegel, M. R. (2019). *Schaum's Outline of Vector Analysis* (2nd ed.). McGraw-Hill.

Electronics-I

BS-Physics

Course Code: PHY-323

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will acquire an understanding of electronic devices and analyze basic electronic circuits.

Learning Outcomes

- Analyze basic electronic circuits involving diodes, transistors, and operational amplifiers.
- Design and construct simple analog circuits.
- Apply the principles of electronics to solve practical problems.

Course Outline

Unit 1. Semiconductor Diode

Metals, insulators and semiconductors, Conduction in Silicon and Germanium. The forbidden energy gap, n and p type semiconductors, the junction diode, diode voltage-current equation, Zener diodes, light emitting diodes, photodiodes, capacitance effects in the pn junction, the half wave rectifier, the full wave rectifier, the bridge rectifier, measurement of ripple factor in the rectifier circuit, the capacitor filter, center-tapped full wave rectifier, diode wave clippers, diode clampers.

Unit 2. Bipolar Junction Transistor and biasing techniques

The structure of bipolar junction transistors, the volt ampere curve of a BJT transistor, the current amplification factors, the load line and Q point, the basic transistor amplifiers, the common emitter amplifier, performance of a CE amplifier, the CB amplifier, the CC amplifier and their comparison. Choice of Q point, variation of Q point, fixed transistor bias, the four-resistor bias circuit, design of a voltage feedback bias circuit, different biasing methods.

Unit 3. Field Effect Transistor

Field effect transistor, JFET: Static characteristics of JFET, Metal oxide semiconductor Field Effect Transistor (MOSFET or IGFET): enhancement and depletion mode, FET biasing techniques, Common drain, common source and common gate fixed bias and self-bias configurations, Darlington pair.

Unit 4. Operational Amplifier and Applications

Ideal and practical op-amp, input parameters of op-amp, common mode rejection ratio, application of op-amp as an inverting amplifier, non-inverting amplifier the integrated amplifier, the differential amplifier, summing amplifier and comparator.

Unit 5. Power Amplifiers

Class A power amplifier, Class B power amplifier, Push-Pull power amplifier.

Recommended books/reference material

1. Floyd, T. L. (2022). *Electronic devices (conventional current version)*, (11th ed.). Pearson.
2. Floyd, T. L., & Buchla, D. M. (2019). *Electronics fundamentals: circuits, devices, and applications*, (8th ed.). Prentice Hall.
3. Paynter, R. T. (2020). *Introductory electronic devices and circuits (conventional flow version)*, (7th ed.). Prentice Hall.
4. Raychaudhuri B. (2022). *Electronics: analog and digital*. Cambridge University Press.

5. Schuler C. A. (2020). *Electronics: principles & applications*. McGraw-Hill Education.
6. Schultz M. E. & Grob B. (2021). *Grob's basic electronics* (13th ed.). McGraw-Hill Education.

Electronics-I (Lab)

BS-Physics

Course Code: PHY-323L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire understanding about the design of electronic circuits. Gain proficiency in using electronic components and measuring instruments and troubleshooting electronic circuits.

Learning Outcomes

- To understand the behavior of basic electronic components and circuits.
- To construct and test circuits using diodes, transistors, and operational amplifiers.
- To measure and analyze the electrical characteristics of semiconductor devices.
- To design and evaluate analog circuits for amplification, rectification, and switching.

Course Outline

1. Series and parallel combination of resistances.
2. I-V characteristic curve of a semiconductor diode.
3. Zener diode as voltage regulator.
4. Half-wave rectification using a diode.
5. Full-wave rectification using a bridge circuit.
6. Measurement of ripple factor in rectifier circuits.
7. Design and testing of a capacitor filter.
8. Diode wave clippers and clampers.
9. Transistor biasing and load line analysis.
10. BJT as an amplifier.
11. BJT as a switch.
12. Common Emitter (CE) amplifier: Design and measurement.
13. Common Base (CB) amplifier: Design and measurement.
14. Common Collector (CC) amplifier: Design and measurement.
15. Op-Amp as an inverting and non-inverting amplifier.
16. Op-Amp as an integrator.
17. Op-Amp as a differentiator.
18. Op-Amp as a comparator (night switch).
19. Class A power amplifier.
20. Class B power amplifier.
21. Push-Pull amplifier.

Recommended books/reference material

1. Brown, E. K., & Zozaya, M. (2022). *Electronics laboratory manual: analog electronics circuits*. Pearson.
2. Floyd, T. L. (2022). *Electronic devices (conventional current version)* (11th ed.). Pearson.
3. Floyd, T. L., & Buchla, D. M. (2020). *Electronics fundamentals: circuits, devices, and applications*, (8th ed.). Prentice Hall.
4. Harrison, J. R., & Robinson, M. A. (2024). *Introduction to electronics lab manual: for physics and engineering students*. Cengage Learning.

5. Paynter, R. T. (2019). *Introductory electronic devices and circuits (conventional flow version)*, (7th ed.). Prentice Hall.
6. Peterson, C. G. (2020). *Digital Electronics Laboratory Manual*. Prentice Hall.
7. Raychaudhuri B. (2022). *Electronics: analog and digital*. Cambridge University Press.
8. Schuler C. A. (2020). *Electronics: principles & applications*. McGraw-Hill Education.
9. Schultz M. E. & Grob B. (2021). *Grob's basic electronics* (13th ed.). McGraw-Hill Education.
10. Smith, A. J. (2017). *Hands-On Electronics: A Practical Introduction to Analog and Digital Circuits*. McGraw-Hill Education.
11. White, F. L. (2018). *Experimental Electronics for Students*. John Wiley & Sons.

Heat and Thermodynamics

BS-Physics

Course code: PHY-212

Credit Hours: 02

Prerequisites: Nil

Objectives

To understand and be able to apply the fundamentals principles and concepts of heat and thermodynamics.

Learning Outcomes

- Apply the laws of thermodynamics to analyze heat engines and refrigerators.
- Analyze the properties of ideal and real gases using kinetic theory.
- Solve problems involving heat transfer and thermal equilibrium.

Course Outline

Unit 1. Temperature and Heat

Concept of temperature and thermal equilibrium, empirical temperature scales including Celsius, Fahrenheit, and Kelvin, definition and measurement of heat, specific heat capacity and calorimetry, heat transfer during phase changes, latent heat and its calculation, thermal expansion of solids, liquids, and gases

Unit 2. First Law of Thermodynamics and Thermodynamic Processes

Definition of internal energy, heat, and work, statement and mathematical formulation of the first law of thermodynamics, application to ideal gases, work done in isothermal, adiabatic, isobaric, and isochoric processes, cyclic processes and energy conservation, introduction to PV diagrams and thermodynamic paths

Unit 3. Kinetic Theory of Gases

Molecular model of an ideal gas, assumptions of kinetic theory, derivation of pressure-volume relation from molecular motion, connection between temperature and average kinetic energy, distribution of molecular speeds, mean free path and collision frequency, behavior of real gases and deviations from ideality

Unit 4. Second Law of Thermodynamics and Entropy

Concept of spontaneous and non-spontaneous processes, heat engines and refrigerators, Carnot engine and its efficiency, Kelvin-Planck and Clausius statements of the second law, concept and calculation of entropy change in reversible and irreversible processes, relation between entropy and disorder, practical implications of entropy increase

Unit 5. Heat Transfer Mechanisms

Conduction and thermal conductivity, Fourier's law of heat conduction, thermal resistance and composite walls, convection and Newton's law of cooling, factors affecting convective heat transfer, radiation and Stefan-Boltzmann law, emissivity and blackbody radiation, practical applications such as insulation and industrial heat exchangers

Recommended Books/Reference Material

1. Blundell S. & Blundell K. M. (2019). *Concepts in thermal physics* (2nd ed.). Oxford University Press.
2. Zemansky, M. W., & Dittman, R. H. (1997). *Heat and Thermodynamics* (7th ed.). McGraw-Hill

3. Cengel, Y. A., & Boles, M. A. (2015). *Thermodynamics: An Engineering Approach* (8th ed.). McGraw-Hill
4. Young, H. D., & Freedman, R. A. (2019). *University Physics with Modern Physics* (15th ed.). Pearson
5. Olafsen J. S. & Sturge M. D. (2020). *Sturge's statistical and thermal physics*. CRC Press Taylor & Francis Group.
6. Schroeder D. V. (2021). *An introduction to thermal physics*. Oxford University Press.

Heat and Thermodynamics (Lab)

BS-Physics

Course code: PHY-212L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire understanding to apply experimental techniques to accurately determine various fundamental physical properties such as temperature, specific heat and explore properties of metals, and gases.

Learning Outcomes

- Perform experiments to verify the fundamental laws of thermodynamics and principles of heat transfer
- Measure thermal properties such as specific heat, thermal conductivity, and efficiency of heat engines
- Analyze experimental data to understand the behavior of ideal and real systems under thermal processes

List of Experiments

1. Determination of specific heat capacity of a solid using the method of mixtures
2. Determination of latent heat of fusion of ice
3. Measurement of thermal conductivity of a metal rod using Searle's apparatus
4. Verification of the first law of thermodynamics using an air pump and pressure-volume data
5. Observation and analysis of adiabatic and isothermal expansion of a gas
6. Study of heat engine efficiency using a mechanical or Joule's paddle wheel apparatus
7. Determination of the coefficient of thermal expansion of a metal rod
8. Newton's law of cooling: determination of cooling constant of a liquid
9. Verification of Boyle's law using a gas syringe setup
10. Verification of Charles's law using a capillary tube and water bath
11. Measurement of emissivity of different surfaces using a radiation cube
12. Study of Stefan-Boltzmann law using a blackbody radiation apparatus

Recommended books/reference material

1. Ghosh, S. K. (2021). *A Textbook of Advanced Practical Physics*. New Central Book Agency.
2. Price, C. B., & Price-Mohr, R. (2020). *Physlab: A 3D Virtual Physics Laboratory of Simulated Experiments for Advanced physics Learning*. Physics Education.
3. Smith, W. F. (2020). *Experimental Physics: Principles and practice for the laboratory*. CRC Press Taylor & Francis Group.
4. Yaakov, K. (2024). *Experiments and Demonstrations in Physics: Bar-Ilan physics laboratory*. World Scientific.
5. Squires, G. L. (2023). *Practical physics* (4th ed.). Cambridge University Press

Classical Mechanics

BS-Physics

Course Code: PHY-305

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will acquire understanding about Newtonian Mechanics, Lagrange Formulation, Variational Principle, Hamiltonian Mechanics, and Central Force Motion

Learning Outcomes

- Apply Newton's laws of motion to analyze the dynamics of particles and rigid bodies.
- Solve problems in Lagrangian and Hamiltonian mechanics.
- Analyze systems under conservative and non-conservative forces.

Course Outline

Unit 1. Review of Newtonian Mechanics

Newton's laws of motion, Linear and angular momentum: Single particle and system of particles, conservation of linear and angular momentum. Energy: Potential energy, kinetic energy, conservative forces and time-dependent potential energy, linear one-dimensional motion, stable and unstable equilibrium

Unit 2. The Lagrange Formulation of Mechanics

Constraints, Cartesian coordinates, generalized coordinates, generalized force, generalized momentum, configuration space, virtual displacement, virtual work done, D'Alembert's principle, Euler Lagrange equation and Applications of the Euler-Lagrange equations, ignorable/cyclic coordinates.

Unit 3. Variational Principle and Hamiltonian Mechanics

Calculus of variations, Fermat's principle, Hamilton's principal and its applications, conservation laws, integrals of motion, non-conservative system, canonical equations, derivation of Lagrange equation from Hamilton's principal.

Unit 4. Hamiltonian Formalism

Legendre transformation, Hamilton's equations, cyclic coordinates, Derivation of Hamilton's equations from Hamilton's Principle, Phase space and Liouville's theorem

Unit 5. Central Force Motion

The two-body problem, effective potential and classification of orbits, Kepler's laws, stability of circular orbits, hyperbolic orbits and Rutherford scattering center of mass coordinate system, scattering cross-section.

Unit 6. The Motion of Rigid Bodies

The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, motion of a torque, stability of rotational motion.

Recommended books/reference material

1. Benacquist M. J., & Romano J. D. (2021). *Classical Mechanics*, Springer
2. Chow T. L. (2023). *Classical Mechanics*, CRC Press.
3. Goldstein H., Poole, C. P., & Safko, J. L. (2020). *Classical Mechanics*, Pearson.
4. Helliwell T. M. & Sahakian V. V. (2021). *Modern classical mechanics*. Cambridge University Press.
5. Kamberaj H. (2021). *Classical mechanics*. De Gruyter.

6. Thornton S. T., & Marion, J. B. (2021). *Classical dynamics of particles and systems*. Cengage Learning.
7. Wiggins S. (2023). *Elementary classical mechanics*. World Scientific.

Electronics-II

BS-Physics

Course Code: PHY-326

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will acquire an understanding of responses and applications of electronic devices.

Learning Outcomes

- Analyze advanced electronic circuits and systems including digital circuits.
- Design and implement complex electronic systems for specific applications.
- Evaluate the performance and functionality of digital systems.

Course Outline

Unit 1. Amplifier Frequency Response

Amplifier frequency response curve and 3 dB point, Low frequency response, High frequency response, total amplifier frequency response curve, The Miller's effect.

Unit 2. Filters

High-pass filters, Low-pass filters, Band-pass filters, Band-stop filters

Unit 3. Oscillators

Damped and un-damped oscillators, the LC oscillatory circuit, frequency stability of an oscillator, essentials of a feedback LC oscillator, tuned based oscillator, Hartley oscillator, Colpitis oscillator, crystal oscillator.

Unit 4. Multi-vibrators

Astable multi-vibrators, Bi-stable multi-vibrators, Mono stable multi-vibrators, Schmitt trigger.

Unit 5. Digital Circuits

Boolean algebra, digital logic gates, K-mapping to form digital circuits, half adder circuit. Full adder circuit, half subtractor circuit and full subtractor circuit.

Recommended books/reference material

1. Floyd, T. L. (2022). *Electronic devices (conventional current version)*, (11th ed.). Pearson.
2. Floyd, T. L., & Buchla, D. M. (2019). *Electronics fundamentals: circuits, devices, and applications*, (8th ed.). Prentice Hall.
3. Paynter, R. T. (2020). *Introductory electronic devices and circuits (conventional flow version)*, (7th ed.). Prentice Hall.
4. Raychaudhuri B. (2022). *Electronics: analog and digital*. Cambridge University Press.
5. Schuler C. A. (2020). *Electronics: principles & applications*. McGraw-Hill Education.
6. Schultz M. E. & Grob B. (2021). *Grob's basic electronics* (13th ed.). McGraw-Hill Education.

Electronics-II (Lab)

BS-Physics

Course Code: PHY-326L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire understanding about the design of electronic circuits. Gain proficiency in using electronic components and measuring instruments and troubleshooting electronic circuits.

Learning Outcomes

- Analyze advanced electronic circuits and systems including digital circuits.
- Design and implement complex electronic systems for specific applications.
- Evaluate the performance and functionality of digital systems.

Course Outline

1. Amplifier frequency response using BJT amplifiers.
2. Low frequency response of transistor as an amplifier.
3. High frequency response of transistor as an amplifier.
4. High Pass filters.
5. Low Pass filters.
6. Band-pass filters.
7. Band-stop filters.
8. Astable multi vibrator.
9. Bi-stable multi vibrator.
10. Mono- stable multi vibrator.
11. Use of different logic gates.
12. Half adder circuit.
13. Full adder circuit.
14. Half subtractor circuit.
15. Full subtractor circuit.

Recommended books/reference material

1. Brown, E. K., & Zozaya, M. (2019). *Electronics laboratory manual: analog electronics circuits*. Pearson.
2. Floyd, T. L. (2022). *Electronic devices (conventional current version)* (11th ed.). Pearson.
3. Floyd, T. L., & Buchla, D. M. (2019). *Electronics fundamentals: circuits, devices, and applications*, (8th ed.). Prentice Hall.
4. Harrison, J. R., & Robinson, M. A. (2022). *Introduction to electronics lab manual: for physics and engineering students*. Cengage Learning.
5. Paynter, R. T. (2023). *Introductory electronic devices and circuits (conventional flow version)*, (7th ed.). Prentice Hall.
6. Peterson, C. G. (2020). *Digital Electronics Laboratory Manual*. Prentice Hall.
7. Raychaudhuri B. (2022). *Electronics: analog and digital*. Cambridge University Press.
8. Schuler C. A. (2020). *Electronics: principles & applications*. McGraw-Hill Education.

9. Schultz M. E. & Grob B. (2021). *Grob's basic electronics* (13th ed.). McGraw-Hill Education.
10. Smith, A. J. (2017). *Hands-On Electronics: A Practical Introduction to Analog and Digital Circuits*. McGraw-Hill Education.
11. White, F. L. (2018). *Experimental Electronics for Students*. John Wiley & Sons.

Mathematical Methods of Physics-I

BS-Physics

Course Code: PHY-302

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will acquire understanding about vectors, tensors, special functions, and complex variables used in physics.

Learning Outcomes

- Apply complex analysis to solve physical problems.
- Use Fourier analysis to solve differential equations in physics.
- Apply linear algebra and vector and tensor calculus to physical systems.

Course Outline

Unit 1. Vector Calculus

Review of vector analysis: definitions, rotation of coordinate axes, scalar product, cross product, addition of vectors, Differential operators, gradient, divergence, curl, integration of vector fields, Gauss' theorem, Stokes' theorem, Gauss' law, Poisson's equation. Definition of delta function, representations including plane wave expansion, generalization to 3 dimensions, vector analysis in curvilinear coordinates, and orthogonal coordinates in R^3 , circular and spherical coordinates.

Unit 2. Tensors

Introduction to tensors, Tensor Algebra, covariant and contra variant tensors, Quotient Rule, Metric Tensor. Cartesian tensors, First- and zero-order Cartesian tensors, second and higher order, Kronecker delta and Levi Civita tensor, Isotropic tensors, improper rotations and pseudo tensors, dual tensors, physical applications of tensors, integral theorems for tensors, non-Cartesian coordinates, the metric tensor, General coordinate transformations and tensors.

Unit 3. Special Functions-I

Bessel functions of first kind, orthogonality, Neumann functions, Bessel functions of the second kind, Hankel functions, modified Bessel functions, asymptotic expansions, spherical Bessel functions,

Unit 4. Special Functions-II

Legendre functions, Legendre polynomials, orthogonality, generating function, recurrence relation, associated Legendre equation, spherical harmonics, orbital angular momentum operator, addition theorem for spherical harmonics, Legendre functions of the second kind, Hermite functions.

Unit 5. Matrices

Linear vector spaces, Determinants, Matrices, Eigen values and eigen vectors of matrices, orthogonal matrices, Hermitian matrices, Similarity transformations, Diagonalization of matrices

Recommended books/reference material

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2020). *Mathematical methods for physicists*. Academic Press.

2. Chow, T. L. (2000). *Mathematical methods for physicists: a concise introduction*. Cambridge.
3. Hassani, S. (2013). *Mathematical physics: a modern introduction to its foundations*. Springer
4. Petrini, M., Pradisi, G., & Zaffaroni, A. (2017). *A guide to mathematical methods for physicists*. World Scientific Press.
5. Riley, K. F., Hobson, M. P., & Bence, S. J. (1999). *Mathematical methods for physics and engineering*. (3rd ed.). Cambridge.
6. Tang K. T. (2022). *Mathematical methods for engineers and scientists 1 complex analysis and linear algebra* (2nd ed.). Springer.
7. Wyld H. W. & Powell G. (2021). *Mathematical methods for physics*. CRC Press.

Electromagnetic Theory

BS-Physics

Course Code: PHY-319

Credit Hours: 03

Prerequisites: Nil

Course Objectives:

This course aims to provide students with a deep understanding of the fundamental principles of electromagnetism, including electrostatics, magnetostatics, and electromagnetic wave propagation.

Learning Outcomes:

- Apply laws of electrostatics and magnetostatics in the presence of medium.
- Apply Maxwell's equations to problems in electromagnetism.
- Analyze the propagation of electromagnetic waves in various media.

Course Outline:

Unit 1. Electrostatics in Vacuum and Material Media

Coulomb's law, electric field, electric flux, Gauss's law and its applications; electrostatic potential, Poisson's and Laplace's equations; boundary conditions; conductors and insulators; dielectric materials, polarization, Gauss's law in dielectrics, electric displacement vector, boundary conditions for electric field at dielectric interfaces.

Unit 2. Magnetostatics and Magnetic Materials

Biot-Savart law, Ampere's law and its applications; magnetic vector potential; magnetization, magnetic susceptibility and permeability; boundary conditions in magnetized materials; magnetic field intensity and auxiliary field; paramagnetism, diamagnetism, and ferromagnetism (qualitative).

Unit 3. Maxwell's Equations and Electromagnetic Fields

Continuity equation; displacement current; Maxwell's equations in differential and integral form; physical interpretation and implications in free space and material media; boundary conditions for electric and magnetic fields.

Unit 4. Electromagnetic Wave Propagation in Free Space

Wave equation from Maxwell's equations; plane wave solutions in vacuum; transverse nature of EM waves; energy transport and Poynting vector; reflection and transmission of EM waves at normal incidence; polarization of electromagnetic waves.

Unit 5. Electromagnetic Waves in Material Media

Wave propagation in dielectric and conducting media; complex permittivity and skin depth; reflection and transmission at dielectric boundaries; oblique incidence and Snell's law for EM waves; applications in waveguides and optical fibers (qualitative).

Recommended Books/Reference Material

1. Davis B. S. (2023). *Understanding the electromagnetic field*. World Scientific.
2. Griffiths D. J. (2019). *Introduction to electrodynamics*, (4th ed.). Prentice Hall.
3. Jackson J. D. (2019). *Classical electrodynamics*, (3rd ed.). John Wiley.
4. Reitz J. R., Milford, F. J., & Christy, R. W. (2009). *Foundation of electromagnetic theory*, (4th ed.). Addison-Wesley.

Quantum Mechanics-I

BS-Physics

Course Code: PHY-303

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will acquire understanding about important postulates of quantum mechanics as well as its mathematical framework and applications.

Learning Outcomes

- Apply the Schrödinger equation to simple quantum systems.
- Analyze the behavior of particles in potential wells and barriers.
- Describe the principles of quantum mechanics and their application to physical systems.

Course Outline

Unit 1. Postulates of Quantum Mechanics

Statement of postulates and their physical interpretation, Observables and operators, Linear operator, State of a system, Wave function and probability density, Eigen value equation, Measurement of eigen values of operators, Normalized, orthogonal & orthonormal set of eigen functions, Degenerate and non-degenerate eigen values, Linearly independent set of eigen vectors, Simultaneous eigen functions, Expectation value of an operator, Time evolution of a system, Time development of expectation values, Superposition principle.

Unit 2. The Mathematical tools of Quantum Mechanics

Linear vector space, Inner product, Hilbert space, Square integrable functions, Dirac notation, Properties of Ket and Bra, Dimensions and basis of vector space, Dirac delta function and its properties, Completeness, Hermitian operators, Projection operators, Commutator algebra, Cauchy Schwarz inequality, Generalized uncertainty relation, Ehrenfest theorem, Probability current density, Matrix representation of Ket, Bra operators, Schrodinger equation of motion, Heisenberg equation of motion, Schrodinger time dependent and time independent Equations.

Unit 3. One Dimensional Applications of Quantum Mechanics

Properties of one dimensional motion (Discrete, Continuous & mixed spectrum), Schrodinger equation for free particle, potential step, potential well, Infinite square well potential (symmetric and asymmetric square well), Finite square well potential (scattering and bound state solutions), Potential barrier, Tunneling effect, Alpha decay, Cold emission. Delta function potential, Harmonic oscillator.

Unit 4. Three Dimensional Applications of Quantum Mechanics

Separation of Schrodinger wave equation in Cartesian coordinates, Free particle in three dimensions, Three-dimensional box (Rectangular and cubical box potential), Three-dimensional harmonic oscillator, Isotropic oscillator.

Unit 5. Angular Momentum in Quantum Mechanics

Orbital angular momentum, Angular momentum in spherical polar coordinates, Eigen values and eigen functions of z component of angular momentum, Simultaneous eigen functions and eigen values of L_z & L^2 , Eigen value spectrum J^2 & J_z , Matrix element of orbital angular momentum and total angular momentum operator.

Recommended books/reference material

1. Berera A. & Del Debbio L. (2022). *Quantum mechanics*. Cambridge University Press.
2. Greiner, W. (1980). *An introduction to quantum mechanics*. Addison Wesley.
3. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to quantum mechanics*, (3rd ed.). Cambridge.
4. Liboff, R. (2002). *Introductory quantum mechanics*, (4th ed.). Addison-Wesley.
5. Sakurai, J. J., & Napolitano, J. J. (2010). *Modern quantum mechanics*, (2nd ed.). Pearson.
6. Zettili N. (2022). *Quantum mechanics: concepts and applications* (3rd ed.). John Wiley & Sons.
7. Zubairy M. S. (2020). *Quantum mechanics for beginners : with applications to quantum communication and quantum computing*. Oxford University Press.

Mathematical Methods of Physics-II

BS-Physics

Course Code: PHY-308

Credit Hours: 03

Prerequisites: PHY-302

Objectives

Students will acquire an understanding of PDE, introduction of special functions, Fourier transforms and their applications, Boundary value problems and their use in Physics.

Learning Outcomes

- Solve advanced differential equations relevant to physics.
- Apply special functions in the solution of physical problems.
- Use variational principles and other mathematical techniques in physical contexts.

Course Outline

Unit 1. Ordinary Differential Equations

First order differential equations, general solution by integration, uniqueness property, Second order differential equations with constant coefficients, Euler linear equations, singular points, series solution by Frobenius' method, solution space, Wronskian, uniqueness

Unit 2. Partial Differential Equation

Introduction to important PDEs in Physics (wave equation, diffusion equation, Poisson's equation, Schrodinger's equation), general form of solution, general and solutions (first order, inhomogeneous, second order), separation of variables in Cartesian coordinates

Unit 3. Complex Variables

Functions of a complex variable, Cauchy-Riemann conditions, power series in a complex variable, singularities and zeroes of complex functions, complex integration, Cauchy's theorem, Cauchy's integral formula, Laurent series and residues, residue integration theorem

Unit 4. Green Functions

Green's Functions, Green's function for one-dimensional problem, eigen function expansion of Green's functions and related problems, Green functions for S.L operator, Boundary value problems and S-L problems along theory and theorem.

Unit 5. Fourier Series, Transforms, and Laplace Transforms

Fourier series and its complex form, Application of Fourier series, Representation of function Fourier integral theorem, Fourier sine and cosine, applications, Laplace transform with all numerical problems, Laplace Application in Physics

Recommended books/reference material

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2020). *Mathematical methods for physicists*. Academic Press.
2. Chow, T. L. (2000). *Mathematical methods for physicists: a concise introduction*. Cambridge.
3. Hassani, S. (2013). *Mathematical physics: a modern introduction to its foundations*. Springer
4. Petrini, M., Pradisi, G., & Zaffaroni, A. (2017). *A guide to mathematical methods for physicists*. World Scientific Press.
5. Riley, K. F., Hobson, M. P., & Bence, S. J. (1999). *Mathematical methods for physics and engineering*. (3rd ed.). Cambridge.

6. Tang K. T. (2022). *Mathematical methods for engineers and scientists 1 complex analysis and linear algebra* (2nd ed.). Springer.
7. Wyld H. W. & Powell G. (2021). *Mathematical methods for physics*. CRC Press.

Electrodynamics and Special Relativity

BS-Physics

Course Code: PHY-324

Credit Hours: 03

Prerequisites: Electromagnetic Theory

Objectives

Students will acquire understanding about static and time dependent electromagnetic fields, and detailed concepts about special and general relativity theories.

Learning Outcomes

- Apply the principles of electrodynamics to analyze electromagnetic waves.
- Solve problems involving the interaction of light and matter.
- Explain the fundamental concepts of special relativity and their application to physical problems.

Course Outline

Unit 1. Electromagnetism

Introduction, comparison of magneto statics and electrostatics, Maxwell equations and their significance in electrodynamics, continuity equation for charge and current, Lorentz and Coulomb gauge conditions, Vector and scalar potentials, electromagnetic waves in vacuum, electromagnetic waves in matter.

Unit 2. Newton versus Einstein

Newtonian mechanics and Galilean transformations. Maxwell's equations invariance. Ether, star aberration, Michelson-Morley experiment. Einstein's postulates, Lorentz's transformations, Generalization of Lorentz's transformations for a generic speed, new composition law for the speed, Relativistic star aberration, Relativistic Doppler's effect for the electromagnetic radiation, Longitudinal and transverse Doppler's effects, Casually connected events, Distance separation between events and its invariance under Lorentz's transformation, Space, time and light like events, Minkowski's space, Euclidean spaces and Pseudo-Euclidean spaces, light cone, future, past and absolute elsewhere of a given event, Relativity of simultaneous events, length contraction and time dilation.

Unit 3. Relativistic Electrodynamics

Four-vectors, four-tensors in Minkowski's space-time, Inner products and Lorentz's invariants, Covariant formulation of the dynamics, Proper time, four-speed and four acceleration, Minkowski's four force, Kinetic energy theorem, energy of a particle at rest and relativistic energy, chemical reactions, fission, and emitted energy from the Sun, Applications of relativistic dynamics, parallel, orthogonal acceleration and inertial mass, The four-momentum and its conservation, Motion of a charge particle inside a constant electromagnetic field, Relativistic harmonic oscillator.

Unit 4. Relativistic Electromagnetism

Covariant formulation of the electromagnetism and Maxwell's equations, Field strength tensor, Four current density, Lorentz's transformations for the four current density, Four potential, Gauge invariance, Lorentz and Coulomb's gauges, Maxwell's equations and their solutions for slow particles in external fields, Four force density, Energy-momentum tensor, Conservation theorems, Relativistic Lagrangian and Hamiltonian of a free particle and of a particle within an external electromagnetic field.

Unit 5. General Theory of Relativity

Einstein's field equations, tests of general theory of relativity, Cosmology, Newtonian cosmology, cosmological redshift, luminosity and redshift relation, Hubble's law, microwave background, the Big Bang, Friedmann models and cosmological constant, FRW metric.

Recommended Books/Reference Material

1. Davis B. S. (2023). *Understanding the electromagnetic field*. World Scientific.
2. Griffiths D. J. (2019). *Introduction to electrodynamics*, (4th ed.). Prentice Hall.
3. Jackson J. D. (2019). *Classical electrodynamics*, (3rd ed.). John Wiley.
4. Reitz J. R., Milford, F. J., & Christy, R. W. (2009). *Foundation of electromagnetic theory*, (4th ed.). Addison-Wesley.
5. Carroll S. M. (2019). *Spacetime and geometry: an introduction to general relativity*. Cambridge University Press.
6. Fayyazuddin F. Riazuddin R. & Aslam J. (2015). *Theory of relativity*. World Scientific.
7. Ferraro R. (2018). *Einstein's space-time: an introduction to special and general relativity* (1st ed.) Springer.

Quantum Mechanics-II

BS-Physics

Course Code: PHY-309

Credit Hours: 03

Prerequisites: PHY-303

Objectives

The course is an extension to the course Quantum Mechanics-I. The students will be introduced to advanced topics such as motion in central potential, spin statistics, perturbation theory, approximation methods for time-dependent problems and scattering theory.

Learning Outcomes

- Solve advanced differential equations relevant to physics.
- Apply special functions in the solution of physical problems.
- Use variational principles and other mathematical techniques in physical contexts.

Course Outline

Unit 1. Motion in a central potential

Hydrogen atom, Energy spectrum, Solution of radial equation and angular equation for H-atom.

Unit 2. Spin Statistics & Addition of Angular Moment

Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, The Pauli spin matrices, The magnetic moment of an electron, Precession of an Electron in a magnetic field. Addition of spins, Clebsch-Gordon coefficients

Unit 3. Approximation methods

Perturbation Theory: Description of the method, Time independent, non-degenerate perturbation theory, one-dimensional harmonic oscillator subjected to a perturbing potential, Stark effect, Time independent Degenerate Perturbation Theory, two-dimensional harmonic oscillator. The Variational method, The WKB approximation, the classical region, potential well with two vertical walls, Tunneling, the connection formulas, potential well with one vertical wall, potential well with no vertical walls.

Unit 4. Systems of Identical Particles

Identical particles, Permutation operators, difference between bosons and fermions, Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom.

Unit 5. Time-Dependent Perturbation Theory

Statement of the problem, approximate solution of the Schrodinger equation, The comparison of quantum pictures, The Interaction picture, Time-Dependent perturbation theory, Transition Probability, Constant perturbation, Sinusoidal Perturbations, Stimulated Emission, Fermi's golden rule.

Unit 6. Scattering by a Potential

Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering amplitude, scattering by a central potential, method of partial waves.

Recommended Books/Reference Material

1. Berera A. & Del Debbio L. (2022). *Quantum mechanics*. Cambridge University Press.
2. Greiner, W. (1980). *An introduction to quantum mechanics*. Addison Wesley.

3. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to quantum mechanics*, (3rd ed.). Cambridge.
4. Liboff, R. (2002). *Introductory quantum mechanics*, (4th ed.). Addison-Wesley.
5. Sakurai, J. J., & Napolitano, J. J. (2010). *Modern quantum mechanics*, (2nd ed.). Pearson.
6. Zettili N. (2022). *Quantum mechanics: concepts and applications* (3rd ed.). John Wiley & Sons.
7. Zurbair M. S. (2020). *Quantum mechanics for beginners : with applications to quantum communication and quantum computing*. Oxford University Press.

Condensed Matter Physics

BS-Physics

Course Code: PHY-325

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will develop an understanding of the fundamental concepts of condensed matter physics, including crystal structure, electronic properties, and various material phenomena. The course will equip students with the ability to analyze the behavior of solids using quantum mechanics and explain key physical properties such as superconductivity, magnetism, and semiconductors.

Learning Outcomes

- Describe the crystal structure and properties of solids.
- Analyze the electronic properties of materials using quantum mechanics.
- Explain phenomena such as superconductivity, magnetism, and semiconductors.

Course Outline

Unit 1. Crystal Structure and Properties of Solids

Crystal lattices and unit cells, Bravais lattices, Miller indices, symmetry operations, types of bonding in solids (ionic, covalent, metallic, van der Waals), crystal defects, X-ray diffraction and Bragg's law.

Unit 2. Lattice Vibrations and Thermal Properties

Phonons, quantization of lattice vibrations, specific heat models (Einstein and Debye), thermal conductivity of solids, anharmonic effects, thermal expansion.

Unit 3. Electronic Properties of Materials

Free electron theory, Bloch's theorem, band structure of solids, density of states, Fermi energy, electrical conductivity in metals, the role of quantum mechanics in determining electronic structure.

Unit 4. Semiconductors and Magnetism

Intrinsic and extrinsic semiconductors, carrier concentration, Fermi level, electrical conductivity, Hall effect, magnetic properties of materials, diamagnetism, paramagnetism, ferromagnetism, hysteresis loop.

Unit 5. Superconductivity and Advanced Topics

Superconductivity: Meissner effect, types of superconductors, BCS theory, Cooper pairs. Introduction to nanomaterials and their applications in modern technology.

Recommended Books/Reference Material

1. Ashcroft, N. W., & Mermin, N. D. (2022). *Solid State Physics*. Cambridge University Press.
2. Blakemore, J. S. (2021). *Solid State Physics*. Cambridge University Press.
3. Hook, J. R., & Hall, H. E. (2018). *Solid State Physics* (2nd ed.). CRC Press.
4. Ibach, H., & Lüth, H. (2019). *Solid-State Physics: An Introduction to Principles of Materials Science* (5th ed.). Springer.
5. Kittel, C. (2020). *Introduction to Solid State Physics* (9th ed.). Wiley.

Nuclear Physics

BS-Physics

Course Code: PHY-428

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will acquire an understanding of nuclear structure, nuclear reactions, and their applications in energy production and radiation detection.

Learning Outcomes

- Describe the structure and properties of atomic nuclei.
- Analyze nuclear reactions and decay processes.
- Apply principles of nuclear physics to energy production and radiation detection.

Course Outline

Unit 1. Structure and Properties of Atomic Nuclei

Nuclear size, mass, charge, spin, parity, magnetic and quadrupole moments; binding energy and mass defect; nuclear stability and valley of stability; semi-empirical mass formula and its use in analyzing nuclear structure.

Unit 2. Radioactive Decay

Alpha, beta (β^- , β^+), and gamma decay; decay law, half-life, and mean life; energy spectra in beta decay and neutrino hypothesis; gamma transitions, nuclear isomerism, and decay chains.

Unit 3. Nuclear Reactions

Types of nuclear reactions, conservation laws, Q-value and reaction energetics; cross-sections and resonance behavior; compound nucleus formation and direct reactions; reaction mechanisms and projectile-target interactions.

Unit 4. Nuclear Models and Nucleosynthesis

Liquid drop and shell models; magic numbers and spin-parity predictions; collective motion and deformation; stellar nucleosynthesis processes (p-p chain, CNO cycle, s- and r-processes); formation of heavy elements in astrophysical sites.

Unit 5. Applications of Nuclear Physics

Nuclear fission and fusion, energy release and criticality; basics of nuclear power; radiation interaction with matter; detectors: ionization chambers, scintillators, and semiconductors; applications in medicine, industry, and archaeology.

Recommended books/reference material

1. Belyaev A. & Ross D. A. (2021). *The basics of nuclear and particle physics*. Springer.
2. Hyde, K. (2004). *Basic ideas and concepts in nuclear physics*. Institute Of Physics Publishing.
3. Krane, K. S. (2020). *Introductory nuclear physics*. John Wiley & Sons.
4. Martin B. R. & Shaw G. (2020). *Nuclear and particle physics : an introduction*. Wiley.
5. Obertelli, A., & Sagawa, H. (2021). *Modern nuclear physics*, Springer Nature Singapore Pte Ltd.
6. Walker J. & Halliday D. (2021). *Halliday's fundamentals of physics*. John Wiley & Sons.

Nuclear Physics (Lab)

BS-Physics

Course Code: PHY-428L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire hands-on experience with experimental methods in nuclear physics. This includes measurement of radiation, verification of decay laws, and the use of detectors and instrumentation relevant to the study of nuclear structure, reactions, and applications.

Learning Outcomes:

- Describe the structure and properties of atomic nuclei through experimental data.
- Analyze nuclear reactions and decay processes using laboratory techniques.
- Apply principles of nuclear physics to study radiation, detection, and safety.

List of Experiments

1. Introduction to Nuclear Instrumentation
2. Counting Statistics and Background Radiation
3. Range and Energy of Alpha Particles
4. Attenuation of Gamma Rays in Matter
5. Verification of the Inverse Square Law for Gamma Radiation
6. Study of the Beta Particle Energy Spectrum
7. Half-Life Determination of a Radioactive Isotope
8. Detection of Cosmic Rays Using a Scintillation Detector
9. Energy Calibration of a Scintillation Detector
10. Coincidence Detection in Radioactive Decay
11. Measurement of Background Radiation Levels
12. Investigation of Radiation Shielding Using Different Materials

Recommended Books/Reference Material

1. Knoll, G. F. (2010). *Radiation Detection and Measurement* (4th ed.). Wiley.
2. Martin, B. R. (2011). *Nuclear and Particle Physics: An Introduction* (2nd ed.). Wiley.
3. Krane, K. S. (1988). *Introductory Nuclear Physics*. Wiley.
4. Leo, W. R. (1994). *Techniques for Nuclear and Particle Physics Experiments* (2nd ed.). Springer.
5. Gilmore, G. (2008). *Practical Gamma-ray Spectrometry* (2nd ed.). Wiley.
6. Obertelli, A., & Sagawa, H. (2021). *Modern Nuclear Physics*. Springer Nature Singapore.
7. Belyaev, A., & Ross, D. A. (2021). *The Basics of Nuclear and Particle Physics*. Springer.

Statistical Mechanics

BS-Physics

Course Code: PHY-429

Credit Hours: 03

Prerequisites: Nil

Objectives

This course introduces the microscopic foundations of thermodynamics through the principles of classical and quantum statistical mechanics. It focuses on linking the microscopic behavior of particles with the macroscopic observables of physical systems and equips students to analyze equilibrium distributions and thermodynamic functions for ideal and real systems.

Learning Outcomes

- Apply the principles of statistical mechanics to explain macroscopic properties of systems.
- Analyze the behavior of systems in thermodynamic equilibrium.
- Solve problems involving the distribution of particles and energy in statistical systems.

Course Outline

Unit 1. Fundamentals of Statistical Mechanics

Concept of microstates and macrostates, phase space and ensemble interpretation, fundamental postulates of statistical mechanics, classical probability distributions, Liouville's theorem, thermodynamic equilibrium and ergodic hypothesis

Unit 2. Microcanonical and Canonical Ensembles

Microcanonical ensemble and entropy definition, derivation of thermodynamic quantities from statistical definitions, canonical ensemble and Boltzmann distribution, partition function and thermodynamic connections, energy fluctuations and heat capacity

Unit 3. Grand Canonical Ensemble and Applications

Grand canonical ensemble and chemical potential, distribution functions for variable particle systems, application to adsorption and photon gas, link between different ensembles and Legendre transformations in thermodynamics

Unit 4. Quantum Statistical Distributions

Indistinguishability and quantum statistics, Fermi-Dirac and Bose-Einstein distributions, classical limit and Maxwell-Boltzmann statistics, application to electron gas and photon gas, derivation of Planck's law, blackbody radiation, Bose-Einstein condensation

Unit 5. Applications and Advanced Topics

Equipartition theorem and classical ideal gas, fluctuations and Brownian motion, paramagnetism and Curie's law, Debye and Einstein models of specific heat, introduction to interacting systems and mean field theory, phase transitions and critical phenomena (qualitative overview)

Recommended Books/Reference Material

1. Blundell, S. (2010). *Concepts in thermal physics* (2nd ed.). Oxford University Press.
2. Gould H. & Tobochnik J. (2021). *Statistical and thermal physics: with computer applications*. Princeton University Press.
3. Huang, K. (2010). *Introduction to statistical physics*. CRC Press.

4. Huang, K. N. (2020). *Quantum statistical thermodynamics*. Springer.
5. Kittel C. (2012). *Elementary statistical physics*. Dover Publications.
6. Pathria, R. K., & Beale, P. D. (2011). *Statistical mechanics* (3rd ed.). Academic Press.
7. Reif, F. (2020). *Fundamentals of statistical and thermal physics*. Waveland.
8. Salinas, S. (2010). *Introduction to statistical physics*. Springer.

Atomic and Molecular Physics

BS-Physics

Course Code: PHY-427

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will gain fundamental understanding of atomic and molecular structure, spectra, and their interactions with radiation. The course emphasizes quantum mechanical models and their application to real physical systems.

Learning Outcomes

- Describe the structure and properties of atoms and molecules.
- Apply quantum mechanical principles to explain atomic and molecular spectra.
- Analyze interactions between radiation and matter at the atomic level.

Course Outline

Unit 1. Atomic Models and Quantum Description of Atoms

Historical background: Rutherford and Bohr models, introduction to quantum theory, quantum numbers and electron configuration, hydrogen atom energy levels.

Unit 2. Fine Structure and Spectral Terms

Quantum spin, spin-orbit coupling, fine structure of hydrogen, term symbols, selection rules, Zeeman effect and Paschen–Back effect.

Unit 3. Multi-Electron Atoms

Pauli exclusion principle, Aufbau principle, LS and jj coupling, periodic table structure, screening and penetration effects.

Unit 4. Molecular Bonding and Structure

Types of molecular bonds (ionic, covalent, van der Waals), molecular orbital theory, bonding in H₂ and O₂, electronic structure of diatomic molecules.

Unit 5. Molecular Spectra and Radiation-Matter Interaction

Rotational, vibrational, and electronic spectra of molecules, Frank-Condon principle, Raman effect, absorption and emission processes, selection rules.

Recommended Books/Reference Material

1. Bransden, B. H., & Joachain, C. J. (2008). *Physics of atoms and molecules*. (2nd ed.) Pearson Education.
2. Brooks, R. L. (2013). *The fundamentals of atomic and molecular physics*. Springer.
3. Cohen-Tannoudji C. (2021). *Atomic and molecular physics*. Collège de France.
4. Demtroder, W., (2010). *Atoms, molecules and photons* (2nd ed.) Springer.
5. Ewart P. (2020). *Atomic physics*. Morgan & Claypool.
6. Foot, C. J., (2005). *Atomic physics*. Oxford University Press.

Atomic and Molecular Physics (Lab)

BS-Physics

Course Code: PHY-427L

Credit Hours: 01

Prerequisites: Nil

Objectives

To experimentally verify theoretical principles of atomic and molecular physics, such as discrete energy levels, atomic spectra, and the interaction of light with matter using spectroscopy and related instrumentation.

Learning Outcomes

- Describe the structure and properties of atoms and molecules through experiments.
- Apply quantum mechanical principles to observe atomic and molecular spectra.
- Analyze interactions between radiation and matter using laboratory techniques.

List of Experiments

1. Study of the hydrogen spectrum and determination of Rydberg's constant
2. Zeeman effect in a magnetic field
3. Measurement of fine structure in sodium D-lines
4. Franck-Hertz experiment to verify quantized energy levels
5. Study of molecular absorption spectra (e.g., iodine vapor)
6. Verification of the Raman effect using laser source
7. Emission spectra of noble gases using a spectrometer
8. Measurement of atomic excitation using discharge tubes
9. Energy gap determination of semiconductors via absorption spectroscopy

Recommended Books/Reference Material

1. Donald, L., & Pavia, G. S., Lampman, G. M., & Kriz, G. S. (2021). *Introduction to spectroscopy*. Cengage Learning.
2. Douglas, A., & Skoog, D. A., Holler, F. J., & Crouch, S. R. (2020). *Principles of instrumental analysis*. Brooks Cole Publications.
3. Guo, C., & Singh, S. C. (Eds.). (2021). *Handbook of laser technology and applications: laser applications: medical metrology and communication* (Volume Four). CRC Press.
4. Jones, K. M., Strait, J., & NECUSE Modern Optics Group. (2021). *Optics and spectroscopy undergraduate laboratory resource book*. Optical Society of America.
5. Poinern, G  rard Eddy Jai. (2020). *A laboratory course in nanoscience and nanotechnology*. CRC Press Taylor & Francis Group.

9. Pool of Field Specific Major Courses in Physics

Sr. No	Course Codes	Course Titles	Prerequisites	Credit hours
1.	PHY-402	Methods of Experimental Physics	Nil	3
2.	PHY-407	Plasma Physics	Nil	3
3.	PHY-408	Laser Physics	Nil	3
4.	PHY-409	Particle Physics	Nil	3
5.	PHY-411	Quantum Information Theory	Nil	3
6.	PHY-412	Introduction to Nanoscience and Nanotechnology	Nil	3
7.	PHY-413	Introduction to Materials Science	Nil	3
8.	PHY-416	Electronic Materials and Devices	Nil	3
9.	PHY-417	Theory of Relativity	Nil	3
10.	PHY-418	Digital Electronics	Nil	3
11.	PHY-421	Physics of Solar Cells	Nil	3
12.	PHY-422	Research Methodologies	Nil	3
13.	PHY-423	Semiconductor Physics	Nil	3
14.	PHY-424	Renewable Energy Sources	Nil	3

10. Course Outlines of Field Specific Major Courses in Physics

Methods of Experimental Physics

BS-Physics

Course Code: PHY-402

Credit Hours: 03

Prerequisites: Nil

Objectives

The course's learning objectives include understanding vacuum techniques radiation detection and measurement, sensor technology, computer fundamentals, and data analysis, covering diverse topics from gas transport to data manipulation techniques.

Learning Outcomes

- Acquisition of skills and knowledge in vacuum techniques
- Competence in working with radiation detection and measurement devices
- Familiarity with various sensor technologies
- Proficiency in utilizing computer interfaces
- Competence in applying data analysis methods in scientific and technical applications

Course Outline

Unit 1. Vacuum Techniques

Gas Transport: Throughout, Pumping Speed, Pump down Time Ultimate pressure, Production of ultrahigh vacuum. Fore-Vacuum Pumps: Rotary Oil pumps, Sorption pumps. Diffusion pumps, Ion pumps, Cryogenic pumps, Turbo molecular pumps. Measurement of total pressure in Vacuums Systems, Units pressure ranges. Vacuum valves: Manometers, Perini gauges, The McLeod gauges, Mass spectrometer for partial measurement of pressure, Design of high pumping vacuum system, Pump Choice, Vacuum Components, vacuum Flanges, Liquid Nitrogen trap, Mechanical feed throughs & Electrical feed throughs Leak detection: Basic consideration, leak detection equipment, Special Techniques and problems, Repair Techniques.

Unit 2. Radiation Detection and Measurement

Scintillation detector, channel Tron, photomultipliers, neutron, detectors, alpha/beta detectors, X-rays/gamma detectors, cosmic rays, detectors, Spectrographs and Interferometers.

Unit 3. Sensor Technology

Sensors for temperature, pressure displacement, rotation, flow, level, speed, rotation position, phase, current voltage, power magnetic field, tilt, metal, explosive and heat.

Unit 4. Computer Introduction

Introduction to computers, GPIB Interface, RS 232. Interfacing.

Unit 5. Data Analysis

Evaluation of measurement: Systematic Errors, Accuracy, Accidental Errors, Precision, Statistical Methods, Mean Value and Variance, Statistical Control of Measurements, Errors

of Direct measurements, Rejection of data, Significance of results, Propagation of errors, preliminary Estimation, Errors of Computation. Least squares fit to a polynomial. Nonlinear functions. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation.

Recommended Books/Reference Material

1. Bevington, P., & Robinson, D. K. (2021). *Data reduction and error analysis for physical science* (3rd ed.). McGraw-Hill.
2. Hablanian, M. H. (2017). *High-vacuum technology* (5th ed.). Marcel Dekker.
3. James, F. (2018). *Statistical methods in experimental physics* (4th ed.). World Scientific Company.
4. Mahamuni, S., Sidhayee, D., & Kulkarni, S. (2021). *Foundations of experimental physics*. CRC Press.
5. Pergament, M. I. (2020). *Methods of experimental physics*. CRC Press Taylor & Francis Group.
6. Zięba, A. (2023). *Analysis of experimental data in science and technology*. Cambridge Scholars Publishing.

Plasma Physics

BS-Physics

Course Code: PHY-407

Credit Hours: 03

Prerequisites: Nil

Objectives

To learn about the importance of plasma along with the basic concept of plasma.

Learning Outcomes

- Know the basic concepts of plasma physics.
- Understand the physics behind plasma and various forms of plasma
- Understand the plasma characteristics, energy distribution function, plasma, Sheath, Debye shielding, plasma frequency.
- Understand the physics of modeling plasmas as fluid.
- Acquire knowledge of the wave propagation in plasmas

Course Outline

Unit 1. Introduction

Occurrence of plasma in nature, Definition of Plasma, Concept of Temperature, Debye Shielding, Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics

Unit 2. Single Particle Motions

Introduction, Uniform E and B fields, Non-uniform B field, Non-uniform E field, Time varying E field, Time varying B field, Adiabatic Functions.

Unit 3. Plasmas as Fluids

Introduction, Relation of Plasma Physics to ordinary electromagnetism, The fluid equation, Fluid drifts perpendicular to B, Fluid drifts parallel to B, The Plasma approximation

Unit 4. Physics as Plasmas

Representation of waves, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Ion Waves, Comparison of electron and ion waves, Electrostatic electron oscillations perpendicular to B, Electrostatic ion waves perpendicular to B, Lower Hybrid Frequency, Electromagnetic waves with $B_0 = 0$, Electromagnetic waves perpendicular to B_0 , Electromagnetic waves parallel to B_0 , Cut-offs and resonances

Unit 5. Introduction to Controlled Fusion

Basic Nuclear Fusion Reactions, Reaction rates and power density, Radiation losses from plasma Basic Nuclear Fusion Reactions, Reaction rates and power density, Radiation losses from plasma.

Recommended Books/Reference Material

1. Chen, F. F. (2021). *Introduction to plasma physics and controlled fusion* (3rd ed.). Plenum.
2. Freidburg, J. P. (2008). *Plasma physics and fusion energy* (1st ed.). Cambridge University Press.

3. Garnett, D. A., & Bhattacharjee, A. (2022). *Introduction to plasma physics: With space and laboratory applications* (3rd ed.). Cambridge University Press.
4. Pert, G. J. (2021). *Foundations of plasma physics for physicists and mathematicians*. John Wiley & Sons.
5. Thorne, K. S., & Blandford, R. D. (2021). *Plasma physics*. Princeton University Press.

Laser Physics

BS-Physics

Course Code: PHY-408

Credit Hours: 03

Prerequisites: Nil

Objectives

The students will be equipped with expertise in practical Laser technologies and develop fundamental concepts and the application of Lasers.

Learning Outcomes

- Predict fundamental and ultimate characteristics of Laser systems based on specific Laser materials such as output power and lasing threshold access and design the optical cavities for different laser systems.
- Solve the rate equations in steady state laser.
- Describe concrete major examples of laser systems in detail and understand their technology.

Course Outline

Unit 1. Introductory Concepts

Spontaneous Emission, Absorption, Stimulated Emission, Pumping Schemes, Absorption and Stimulated Emission Rates, Properties of Laser Beam, Three level laser, Modes of a rectangular cavity, Raleigh-Jeans and Planck radiation formula black-body radiation theory

Unit 2. Semi-classical treatment of the interaction of radiation and matter

Radiative transition rates, Interaction Hamiltonian, dipole approximation, rotating-wave approximation, electric dipole moment, allowed and forbidden transitions, ratio of the electric-dipole transition probability to the magnetic dipole transition probability, transition cross-section, and absorption and gain coefficients.

Unit 3. Line-broadening mechanisms

Homogeneous broadening, collision broadening and natural broadening. Wiener-Kinchine and Parseval's theorem. Inhomogeneous and Doppler broadening.

Unit 4. Rate equation approach to Laser theory

Stationary solution, Time-dependent solution, Gain, loss and saturation parameters, Lasing condition.

Unit 5. Ray and wave propagation in optical media.

Matrix formulation of Geometrical optics, Wave reflection and transmission at a dielectric interface, Diffraction optics in paraxial approximation.

Unit 6. Passive optical resonators

Plane-parallel (Fabry-Perot) resonator, Concentric, Confocal, Generalized spherical and ring resonator, Eigen-modes and Eigen-values, Stability condition, Unstable resonator, Photon lifetime and cavity Q.

Unit 7. Q-switching and Mode Locking

Q-switching, Electro-optical, and acousto-optic Q-switches, Saturable absorber Q-switch.
Theory of mode-locking, active and passive mode-locking

Unit 8. Laser excitation techniques and types of laser

Optical, electrical, and chemical pumping, laser pumping, excitation, transfer, meta-stable states, and lifetimes solid-state, dye and semiconductor lasers, gas, chemical, free electron, and X-ray lasers, laser applications.

Recommended Books/Reference Material

1. An K. (2023). *Fundamentals of laser physics*. World Scientific Publishing Co.
2. Bisht P. (2022). *An introduction to photonics and laser physics with applications*. IOP Publishing.
3. Hooker S. & Webb C. E. (2010). *Laser physics*. Oxford University Press.
4. Renk, K. F. (2021). *Basics of laser physics: for students of science and engineering* (2nd ed.). Springer.
5. Sargent M. Scully M. O. & Lamb W. E. (2018). *Laser physics*. CRC Press.
6. Sargent M. Scully M. O. & Lamb W. E. (2020). *Laser physics*. CRC Press.
7. Scully, M. O., & Zubairy, M. S. (1997). *Quantum optics*. Cambridge University Press.
8. Svelto, O. (2009). *Principles of lasers* (5th ed.). Springer.

Particle Physics

BS-Physics

Course Code: PHY-409

Credit Hours: 03

Prerequisites: Nil

Objectives

To study the smallest building blocks of the universe to understand unanswered questions about dark matter, antimatter and the origin and evolution of the universe.

Learning Outcomes

- To understand all leptons and quarks and their combinations.
- Be able to describe how particles interact with matter, and how this determines how particle detectors work
- To provide a non-mathematical description of the Standard Particle Physics Model, which includes the smallest constituents of matter and the forces acting between these particles. This includes the quantum mechanical properties of the particles, and how to draw up the Feynman charts to describe the interactions between them.
- Explain how the most important elemental particles decompose, and how this determines how particle collision analysis is performed.

Course Outline

Unit 1. Introduction to Elementary Particles

Fundamental building blocks and their interactions. Quantum Electrodynamics. Quantum Chromodynamics. Weak interactions. Decays and conservation laws.

Unit 2. Relativistic Kinematics

Lorentz transformations. Four-Vectors. Energy and momentum. Particle collisions. Mandelstam variables.

Unit 3. Symmetries

Symmetries and conservation laws, Spin and orbital angular momentum. Flavor symmetries. Parity. Charge conjugation. CP Violation. Time reversal and TCP Theorem.

Unit 4. Quantum Electrodynamics

Klein-Gordon equation. Dirac equation. Solution of Dirac equation. Bilinear covariants. Feynman rules for QED. Casimir's trick. Cross sections & lifetimes.

Unit 5. Gauge Field Theories

Lagrangian in Relativistic Field Theory. Gauge Invariance. Yang-Mills Theory. Higgs mechanism. Higgs boson. Grand Unification. Supersymmetry.

Recommended Books/Reference Material

1. Carlsmith D. L. (2013). *Particle physics*. Pearson.
2. Dunlap R. A. & Institute of Physics. (2020). *Particle physics*. Morgan & Claypool.
3. Griffiths, D. (2021). *Introduction to elementary particles* (2nd ed.). Wiley-VCH.

4. Halzen, F., & Martin, A. D. (2015). *Quarks and leptons: an introductory course in modern particle physics*. John Wiley.
5. Horváth Dezső & Trócsányi Zoltán. (2019). *Introduction to particle physics*. Cambridge Scholars Publishing.
6. Larkoski A. J. (2019). *Elementary particle physics : an intuitive introduction*. Cambridge University Press.
7. Perkins, D. H. (2000). *Introduction to high-energy physics* (4th ed.). Cambridge University Press.
8. Rubbia André. (2022). *Phenomenology of particle physics*. Cambridge University Press.

Quantum Information Theory

BS-Physics

Course Code: PHY-411

Credit Hours: 03

Prerequisites: Nil

Objectives

To understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation.

Learning Outcomes

- Mastery of quantum mechanics fundamentals, including postulates, states, and observables using Dirac notation
- Exploration of projective measurements, entanglement, and tensor products
- Overview of quantum information, covering the no-cloning theorem, mixed states, Schmidt decomposition, and density operator concepts
- In-depth study of quantum communication, quantum computation, and entropy, including dense coding, teleportation, quantum key distribution, algorithms, qubit operations, universal gates, entropy types, and their basic properties

Course Outline

Unit 1. Review of Quantum Mechanics

Postulates of quantum mechanics, Quantum states and observables, Dirac notation, Projective measurements, Entanglement, Tensor products.

Unit 2. Overview of Quantum information

No-cloning theorem, Mixed states from pure states in a larger Hilbert space, Schmidt decomposition, Qualitative overview of Quantum Information.

Unit 3. The Density Operator

Ensemble of quantum states, General properties of density operator, Reduced density operator, Postulates of quantum mechanics in density operator formalism, Schmidt decomposition and purification

Unit 4. Quantum Communication

Dense coding, Teleportation, Entanglement swapping, Instantaneous transfer of information, Quantum key distribution.

Unit 5. Quantum Computation

Quantum algorithms, Single and qubit operations, Controlled operations, Universal quantum gates, Quantum copying circuit, Quantum teleportation and super dense coding

Unit 6. Entropy and information

Shannon entropy, Basic properties of entropy, Binary entropy, Relative entropy, Conditional entropy and mutual information, Von-Neuman entropy and its basic properties.

Recommended Books/Reference Material

1. Nielsen, M., & Chuang, I. (2010). *Quantum computation and quantum information* (10th ed.). Cambridge.
2. Parthasarathy H. (2023). *Classical and quantum information theory for the physicist*. CRC Press.
3. Steeb, W., & Hardy, Y. (2011). *Problems and solutions in quantum computing and quantum information* (3rd ed.). World Scientific Publishing.
4. Vedral, V. (2007). *Introduction to Quantum information science*. Oxford.
5. Wilde M. M. (2022). *Quantum information theory* (3rd ed.). Cambridge University Press.

Introduction to Nanoscience and Nanotechnology

BS-Physics

Course Code: PHY-412

Credit Hours: 03

Prerequisites: Nil

Objectives

To develop understanding of nanoscience and its applications

Learning Outcomes

- Foundations of nanoscience and nanotechnology, including historical perspectives and societal implications
- Understanding of nanostructures (0D to 3D), fabrication techniques (top-down and bottom-up)
- Familiarity with characterization instruments like XRD, SEM, and TEM
- Exploration of diverse nanomaterials, including carbon-based nanomaterials, semiconductor nanoparticles, metals, oxides, and quantum dots, along with their growth and applications

Course Outline

Unit 1. Introduction to Nanoscience and Nanotechnology

Feynman talks on small structures, Nano scale dimension, Historical perspectives of Nanotechnology, Advance Materials, Nature's take on Nano and the Advent, Business of Nanotechnology, Education and Workforce Development, Buildings for Nanotech, National and International Infrastructure, Nanotechnology Products.

Unit 2. Societal Implications of Nanotechnology

Introduction to Societal Issues, Ethical implications, Legal Implications, Environmental implications, Public perception, Future of Nanotechnology.

Unit 3. Nanostructures

0D, 1D, 2D and 3D (Quantum dots, thin films, nano wires, nano rods, Nano ribbons, Nano flowers, dendrites and etc.)

Unit 4. Fabricating Nano Structures

Top-Down Fabrication, Bottom-Up Fabrication, physical and chemical methods of fabrication thin films and nanoparticles. (Chemical vapor deposition, Physical vapor deposition, Lithography (photo and electron beam), Molecular beam epitaxial growth (MBE), Self-assembled masked, Forced Ion Beam (FIB), Sputtering, Thermal evaporation, Micro emulsion, Sol gel).

Unit 5. Characterization Instrument and Nano Structure

XRD, optical microscope, Electron Microscopy, SEM, TEM, STM, AFM, UV/IR spectroscopy.

Unit 6. Nano Materials

Carbon-Based Nanomaterials: Diamond, Fullerenes, Graphene, Carbon Nano tubes, properties and types CNT's, Growth and applications of CNT's, Nano materials natural and manmade. Semiconductor Nano particles, Nanotubes, Metals, Oxides, Quantum dots, Nano catalysis.

Recommended Books/Reference Material

1. Andrews D. L. Lipson R. H. & Nann T. (2020). *Comprehensive nanoscience and nanotechnology*. Academic Press.
2. Binns C. (2010). *Introduction to nanoscience and nanotechnology*. Wiley.
3. Choudhary K. K. (2023). *Nanoscience and nanotechnology*. Alpha Science International.
4. Kumar N. & Kumbhat S. (2020). *Essentials in nanoscience and nanotechnology*. Wiley.
5. Lindsay, S. (2009). *Introduction to Nanoscience*. Oxford University Press.

Introduction to Materials Science

BS-Physics

Course Code: PHY-413

Credit Hours: 03

Prerequisites: Nil

Objectives

To develop understanding about material science and microstructures.

Learning Outcomes

Upon completion of the course, participants will have

- Comprehensive understanding of atomic structure in materials
- Insight into imperfections in solids and microstructures
- Knowledge of the mechanical behavior of materials
- Fundamentals of polymers
- Ability to analyze and apply these concepts in materials science and engineering applications

Course Outline

Unit 1. Atomic Structure of Materials

Atomic Structure of Materials: The packing of atoms in 2-D and 3-D, unit cells of the hexagonal close packing (hcp) and cubic closed packing (ccp) structures, interstitial structures, density computation, lattices, and symmetry elements, indexing lattice directions and lattice planes, interplanar spacing, lattices and crystal systems in 3-D, symmetry, crystallographic point groups and space groups, Bragg's law and the intensities of Bragg reflections.

Unit 2. Imperfections in Solids

1D, 2D, 3D defects (Vacancies, impurities, dislocations, interfacial defects, bulk, or volume defects.)

Unit 3. Micro-Structures

Microstructure and microscopy, pressure vs temperature phase diagrams, temperature vs. composition phase diagrams, equilibrium, thermodynamic functions.

Unit 4. Mechanical Behavior of materials

Normal stress and normal strain, shear stress and shear strain, elastic deformation, plastic deformation, Young's modulus, shear modulus, and Poisson's ratio.

Unit 5. Polymers

Polymer basics, polymer identification, polymer molecules, additional polymerization, step growth polymerization, measurement of molecular weight, thermosetting polymers and gels, rubbers and rubber elasticity, configuration and conformation of polymers, the glassy state and glass transition, determination of T_g, effect of temperature and time, mechanical properties of polymers, case studies in polymer selection and processing.

Recommended Books/Reference Material

1. Askeland D. R. & Wright W. J. (2020). *Essentials of materials science and engineering*. Cengage.
2. Boling M. (2021). *Materials science*. Learning Press.
3. Callister, W. D., Jr., & Rethwisch, D. G. G. (2021). *Materials science and engineering: An Introduction* (10th ed.). John Wiley and Sons, Inc.
4. Cullity, B. D., & Graham, C. D. (2008). *Introduction to magnetic materials* (2nd ed.). John Wiley and Sons, Inc.
5. Horath, L. D. (2006). *Fundamentals of material science* (3rd ed.). Prentice Hall.
6. Smith, W. F. (2004). *Foundations of materials science and engineering* (3rd ed.). McGraw-Hill.
7. Sutton A. P. (2021). *Concepts of materials science*. Oxford University Press.

Electronic Materials and Devices

BS-Physics

Course Code: PHY-416

Credit Hours: 03

Prerequisites: Nil

Objectives

To understand the relation between electrical, optical, and magnetic devices.

Learning Outcomes

- Comprehensive understanding of semiconductor fundamentals
- Knowledge of device fabrication processes
- Understanding of PN junctions and bipolar junction transistors
- Familiarity with dielectric materials, optoelectronic devices, and magnetism
- Ability to apply these concepts in the design and analysis of electronic and optoelectronic systems

Course Outline

Unit 1. Semiconductor Fundamentals

Composition, purity and structure of semiconductors, energy band model, band gap and materials classification, charge, effective mass and carrier numbers, density of states, the Fermi function and equilibrium distribution of carriers, doping, n and p-type semiconductors and calculations involving carrier concentrations, E_F etc., temperature dependence of carrier concentrations, drift current, mobility, resistivity and band bending, diffusion and total currents, diffusion coefficients, recombination-generation, minority carrier life times and continuity equations with problem solving examples.

Unit 2. Device Fabrication Processes

Oxidation, diffusion, ion implantation, lithography, thin-film deposition techniques like evaporation, sputtering, chemical vapor deposition (CVD), epitaxy etc.

Unit 3. PN Junction and Bipolar Junction Transistor

Junction terminology, Poisson's equation, qualitative solution, the depletion approximation, quantitative electrostatic relationships, ideal diode equation, non-idealities, BJT fundamentals, Junction field effect transistor, MOS fundamentals, the essentials of MOSFETs.

Unit 4. Dielectric Materials

Polarization mechanisms, dielectric constant and dielectric loss, capacitor dielectric materials, piezoelectricity, ferroelectricity and pyroelectricity.

Unit 5. Optoelectronic Devices

Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics, solar cell basics, LEDs, Lasers, displays, LCDs.

Unit 6. Magnetism and Magnetic Materials

Basics of magnetism, hysteresis loops, magnetic domains and anisotropy, hard and soft magnetic materials, transformers, DC motors and data storage.

Recommended Books/Reference Material

1. Ghosh A. (2023). *Fundamentals of electronic materials and devices : a gentle introduction to the quantum-classical world*. World Scientific.
2. Kasap S. (2018). *Principles of electronic materials and devices*. McGraw-Hill Education.
3. Poplavko, Y. (2018). *Electronic materials, principles, and applied science* (1st ed.). Elsevier.
4. Rezende, S. M. (2022). *Introduction to electronic materials and devices*. Springer.
5. Waser R. (2012). *Nanoelectronics and information technology : advanced electronic materials and novel devices*. Wiley-VCH.

Theory of Relativity

BS-Physics

Course Code: PHY-417

Credit Hours: 03

Prerequisites: Nil

Objectives

To develop understanding of the special and general relativity theories and cosmology.

Learning Outcomes

- Comprehend Einstein's special relativity, focusing on postulates, Lorentz transformations, and Minkowski spacetime tensors.
- Explore the contrast between Newtonian and Einsteinian perspectives, including concepts like the light-cone, four-vectors, and the relativity of simultaneity.
- Investigate force equations, energy conservation, and Maxwell's equations in covariant form within the framework of special relativity.
- Grasp tensor calculus elements and cosmic dynamics, encompassing manifolds, geodesics, and the principles of general relativity.
- Extend understanding to cosmic microwave background, Einstein's field equations, tests of general relativity, cosmology, Hubble's law, and the Big Bang theory.

Course Outline

Unit 1. Introduction

Einstein's postulates of special relativity, Lorentz transformations, structure of spacetime, Minkowski spacetime tensors.

Unit 2. Newton versus Einstein

The light-cone, line element, four-vectors, relativity of simultaneity, velocity transformation and velocity addition. Force equation in relativity, rest mass, kinetic and total energy, conservation of energy and momentum.

Unit 3. Relativistic Electromagnetism

Covariant form of Maxwell's equations, four vector potential and field strength tensor. Elements of Tensor Calculus.

Unit 4. Cosmic Dynamics

Manifolds and coordinates, curves and surfaces, tensor fields, geodesics, Riemann tensor, Bianchi identity, metric tensor, Ricci tensor, Einstein's tensor. General Relativity, Principles of general relativity, weak and strong equivalence principle, equation of geodesics deviation.

Unit 5. Cosmic Microwave Background

Einstein's field equations, tests of general theory of relativity, Cosmology, Newtonian cosmology, cosmological redshift, luminosity and redshift relation, Hubble's law, microwave background, the Big Bang, Friedmann models and cosmological constant, FRW metric.

Recommended Books/Reference Material

1. Carroll, S. M. (2019). *Spacetime and geometry: an introduction to general relativity*. Cambridge University Press.
2. Fayyazuddin F. Riazuddin R. & Aslam J. (2015). *Theory of relativity*. World Scientific.
3. Ferraro, R. (2007). *Einstein's space-time: an introduction to special and general relativity* (1st ed.). Springer.
4. Ghatak A. K. (2009). *Special theory of relativity*. Anshan.
5. Narlikar, J. V. (2002). *Introduction to cosmology* (3rd ed.). Cambridge University Press.
6. Parnovsky, S., & Parnowski, A. (2018). *How the universe works: introduction to modern cosmology*. World Scientific Publishing.

Digital Electronics

BS-Physics

Course Code: PHY-418

Credit Hours: 03

Prerequisites: Nil

Objectives

To learn the basics of digital electronics such as Boolean Algebra. To develop logic circuit using the Boolean Algebra. To understand the computer interface and micro-controller along with the embedded systems.

Learning Outcomes

- Master number systems and Boolean algebra, including binary, octal, and hexadecimal conversions.
- Understand logic concepts, truth tables, basic logic gates, and Boolean simplification techniques.
- Explore IC logic families (DTL, RTL, ECL, TTL, CMOS) and combinational logic circuits (AND, OR, NAND, NOR).
- Study sequential logic circuits, including flip-flops, shift registers, and counters.
- Gain insights into memory devices (ROM, PROM, RAM), microcomputers, and microprocessor fundamentals (8085/8088, 8086), as well as microcontrollers and embedded systems.

Course Outline

Unit 1. Review of Number system and Boolean Algebra

Binary, Octal and Hexadecimal number system, their inter-conversion, concepts of logic, truth table, basic logic gates. Boolean Algebra: De Morgan's theorem, simplification of Boolean expression by Boolean Postulates and theorem, K -maps and their uses. Different codes. (BCD, ASCII, Gray etc.). Parity in codes.

Unit 2. IC logic Families and combinational logical circuit

Basic characteristics of a logic family. (Fan in/out, Propagation delay time, dissipation, noise margins etc. Different logic based IC families (DTL, RTL, ECL, TTL, CMOS). Combinational Logic Circuit: Logic circuits based on AND – OR, OR-AND, NAND, NOR Logic, gate design, addition, subtraction (2's compliments, half adder, full adder, half subtractor, full subtractor encoder, decoder, PLA. Exclusive OR gate.

Unit 3. Sequential Logic circuit

Flip-flops clocked RS-FF, D-FF, T-FF, JK-FF, Shift Register, Counters (Ring, Ripple, up-down, Synchronous) A/D and D/A Converters.

Unit 4. Memory devices and Micro Computers

Memory Devices: ROM, PROM, EAPROM, EE PROM, RAM, (Static and dynamic) Memory mapping techniques Micro Computers: Computers and its types, all generation of computers, basic architecture of computer, micro-processor (ALU, UP Registers, Control and Time Section). Addressing modes, Instruction set and their types, Discussion on 8085/8088, 8086 processor family, Intel Microprocessor Hierarchy.

Unit 5. Micro-controller/ Embedded System

Introduction to Embedded and microcontroller-based systems, The Microprocessor and microcontroller applications and environment, microcontroller characteristics, features of a general purpose microcontroller, Microchip Inc and PIC microcontroller, Typical Microcontroller examples, Philips 80C51 & 80C552 and Motorola 68Hc05/08, Interfacing with peripherals.

Recommended Books/Reference Material

1. Floyd, T. L. (2014). *Digital Fundamentals* (11th ed.). Pearson.
2. Ghosh B. (2024). *Basics of digital electronics*. CRC Press Taylor & Francis Group.
3. Mono, M. M. (1995). *Digital logic and computer design*. Prentice Hall.
4. Natarajan D. (2020). *Fundamentals of digital electronics*. Springer.
5. Tokheim R. L. & Hoppe P. E. (2022). *Digital electronics: principles and applications* (9th ed.). McGraw-Hill.

Physics of Solar Cells

BS-Physics

Course Code: PHY-421

Credit Hours: 03

Prerequisites: Nil

Objectives

To get the understanding of the importance of new energy resources and the need for it to enable students to discover more such material which bring revolutionary change in field.

Learning Outcomes

- Understand solar radiation fundamentals, encompassing the radiation spectrum, extraterrestrial radiation, and solar day length.
- Grasp solar cell basics, focusing on mechanisms, pn-junction, and electric field effects.
- Explore circuits, covering short-circuit and open-circuit limits, temperature effects, and fill factor losses.
- Examine solar cell structure considerations, addressing optimal design, carrier collection probability, doping, and limitations like dead layers.
- Explore solar cell limitations and uses, including maximum efficiency, thin film cells, and applications in water pumping, residential systems, and space power plants.

Course Outline

Unit 1. Solar Radiation

Introduction, radiation spectrum from sun and earth, extraterrestrial radiation, latitude and longitude sunrise, sunset, and solar day length.

Unit 2. Solar Cell Basics

Introduction, Basic mechanisms in solar cells, dye solar cell, the pn-junction, the role of electric field on solar cell.

Unit 3. Circuits

Short-circuit current limits, open-circuit voltage limits, effect of temperature short -circuit current losses, open-circuit voltage losses, fill factor losses.

Unit 4. Solar Cell Structure

Optimal cell design considerations, collection probability of generated carriers, junction depth, lateral resistance of top layer, doping of substrates, back surface fields, top layer limitations, dead layers and high doping effects.

Unit 5. Limitations and Uses of solar cells

Limitations on energy conversion in solar cells: Introduction: maximum efficiency of solar cells, thin film solar cells, minimal thickness of a solar cells, efficiencies of the individual energy conversion process in water pumping and in residential systems, central power plants for space applications.

Recommended Books/Reference Material

1. Bisquert J. (2020). *The physics of solar energy conversion*. CRC Press.
2. Chen C. J. (2011). *Physics of solar energy*. John Wiley & Sons.
3. Jaffe R. L. & Taylor W. (2018). *The physics of energy*. Cambridge University Press.
4. Jena D. (2022). *Quantum physics of semiconductor materials and devices*. Oxford University Press.
5. Pandikumar A. & Ramaraj R. (2021). *Rational design of solar cells for efficient solar energy conversion*. John Wiley & Sons.
6. Würfel Peter & Würfel Uli. (2021). *Physics of solar cells : from basic principles to advanced concepts* (3rd ed.). Wiley VCH.

Research Methodologies

BS-Physics

Course Code: PHY-422

Credit Hours: 03

Prerequisites: Nil

Objectives

This course aims to provide students with a foundational understanding of research methodology, covering the meaning, objectives, and importance of research, as well as criteria for good research and common challenges faced by researchers in Pakistan. Students will also learn essential skills such as defining research problems, understanding research design, sampling design, and utilizing computers in research. The course further focuses on interpretation, report writing techniques, and ethical considerations in academic paper composition, including addressing plagiarism.

Learning Outcomes

- Grasp research methodology fundamentals, including the meaning, objectives, and importance of research criteria.
- Learn to define research problems and explore features of research design and sampling design concepts.
- Understand the role of computers in research, focusing on applications and the use of various software.
- Acquire skills in interpretation, report writing, and academic paper composition, covering techniques, layout, precautions, and ethical considerations.
- Develop awareness of ethical considerations such as avoiding plagiarism in research activities.

Course Outline

Unit 1. Introduction to Research Methodology

Meaning of Research, Objective of Research, and Importance of knowing how Research is Done, Criteria of Good Research, and Problems Encountered by Researchers in Pakistan.

Unit 2. Defining the Research Problem

What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique involved in Defining a Problem, An Illustration, Conclusion.

Unit 3. Research Design

Meaning of Research Design, Need for Research Design, Features of a Good Design.

Unit 4. Sampling Design

Census and Sample Survey, Implication of a Sample Design, Steps in Sampling Design, Characteristics of a Good Sample Design.

Unit 5. The Computer: Its Role in Research

Introduction, the computer and computer Technology, The Computer System, Computer Applications, Computer and Researcher, Use of Different Software.

Unit 6. Interpretation and Report Writing

Meaning of Interpretation, Technique of Interpretation, Significance of Report Writing, Layout of Research Report, Precautions for Writing Research Reports.

Unit 7. Writing Academic Papers

Writing and Presentation of Scientific Papers, Plagiarism and how to avoid it, Contents and Referencing Writing Papers.

Recommended Books/Reference Material

1. Flick U. (2020). *Introducing research methodology : thinking your way through your research project*. SAGE.
2. Hughes, I., & Hase, T. P. A. (2010). *Measurements and their uncertainties a practical guide to modern error analysis*, OUP.
3. Kothari, C.R. (2021). *Research methodology: methods and techniques*. New Age International Publishers, New Delhi.
4. Kumar R. (2020). *Research methodology : a step-by-step guide for beginners*. SAGE.
5. Marder, M. P. (2021). *Research methods for science*. Cambridge University Press.
6. Walliman N. (2011). *Research methods : the basics*. Routledge.

Semiconductor Physics

BS-Physics

Course Code: PHY-423

Credit Hours: 03

Prerequisites: Nil

Objectives

To get the understanding of semiconductor material which is a building block of electronics.

Learning Outcomes

- Grasp elementary theory of semiconductors, including conduction processes, carrier density control, and energy levels in crystalline solids.
- Understand carrier concentration in thermal equilibrium, electron transport phenomena, and thermal/electrical properties like conductivity and thermoelectric power.
- Explore diffusion of electrons and holes, PN-junctions (including space charge regions and breakdown).
- Learn about applications such as rectifiers, transistors, and photodiodes.
- Gain a comprehensive understanding of semiconductor physics and technology.

Course Outline

Unit 1. Elementary Theory Of Semiconductors

Elementary theory of semiconductors, conduction processes, control of carrier density, binary compounds, oxides, organic and magnetic semiconductors Energy levels in crystalline solids, wave mechanics of free electrons, motion in a periodic potential. Form of the energy bands, positive holes, Energy level diagrams.

Unit 2. Carrier Concentration At Thermal Equilibrium

Carrier concentration in thermal equilibrium Distribution of elections between the various energy levels, intrinsic semiconductors, Semiconductors with impurity levels, Electron transport phenomena constant relaxation time, Hall Effect, Transverse magneto resistance, scattering mechanics.

Unit 3. Thermal And Electrical Properties

Thermal conductivity, thermoelectric power, thermomagnetic effects, the fundamental absorption, free carrier absorption, impurity absorption, Lattice absorption.

Unit 4. Diffusion Of Electrons And Holes

Einstein relationship, Diffusion and conduction in extrinsic material, Continuity equation, Near intrinsic material recombination mechanisms, the element of semiconductors Si, Ge.

Unit 5. PN- Junctions

Electrostatics, Space Charge region of step-junctions, space charge region of linearly graded junctions, space charge region of diffused junctions, capacitance-voltage Characteristics, Current-Voltage characteristics, junction break down, transient behavior,

junction diodes, Tunnel diode, photodiodes, light emitting diodes and lasers, Avalanche Photodiodes.

Unit 6. Applications Of Semiconductors

Rectifiers, Transistors, Photodiodes, Photocells.

Recommended Books/Reference Material

1. Böer K. W & Pohl U. W. (2023). *Semiconductor physics*. Springer.
2. Evstigneev M. (2022). *Introduction to semiconductor physics and devices*. Springer.
3. Kono, J. (2023). *Quantum mechanics for tomorrow's engineers* (1st ed.). Cambridge University Press.
4. Miller, D. A. B. (2008). *Quantum mechanics for scientists and engineers*. Cambridge University Press.
5. Muller, R. S., Kamins, T. I., & Chan, M. (2003). *Device electronics for integrated circuits*. (3rd ed.). John Wiley & Sons, Inc.
6. Neamen, D. A. (2012). *Semiconductor physics and devices: Basic principles* (4th ed.). McGraw-Hill.
7. Tiwari S. (2020). *Semiconductor physics : principles theory and nanoscale*. Oxford University Press.

Renewable Energy Sources

BS-Physics

Course Code: PHY-424

Credit Hours: 03

Prerequisites: Nil

Objectives

The course aims to provide a comprehensive understanding of renewable energy sources, covering solar and wind energy, biomass, biogas, geothermal energy, wave energy, and ocean thermal energy. Students will explore the potential and present status of these sources, as well as their applications, advantages, and limitations.

Learning Outcomes

- Understand global and local energy demand, distinguishing between conventional and renewable sources.
- Explore the potential and present status of renewable energy sources.
- Delve into solar and wind energy, covering solar collectors, flat-plate collection, windmill types, and wind speed variations.
- Discuss biomass and biogas, including classification, energy plantation, alternative fuels, and biogas plant models.
- Explore geothermal energy sources, covering power plants, hydrothermal and petro-thermal resources, with advantages and limitations. Additionally, touch on wave energy devices and ocean thermal energy conversion systems, highlighting their merits and demerits.

Course Outline

Unit 1. Renewable Energy Sources

Introduction, importance of energy, world energy demand, Pakistan demand. Conventional v/s Renewable Energy Sources: Conventional energy sources, renewable energy sources, potential availability, and present status of renewable energy sources.

Unit 2. Solar Energy & Wind Energy

Solar energy: Introduction; classification of solar collectors, flat-plate collection, solar energy storage. Wind Energy: Introduction: basic principles and components of wind energy, Global wind, local wind, types and performance of windmills, collecting data about wind speed, wind speed variations with height, Meteorology departments.

Unit 3. Biomass & Biogas

Biomass: Introduction: Biomass classification, biomass resources' development and energy plantation, alternative liquid fuels, biogas generation, classification of biogas plants. Biogas: Introduction, aerobic and anaerobic process, application of biogas in IC engine, models of biogas plants.

Unit 4. Geothermal Energy Sources

Introduction: Resources of Geothermal energy, Geothermal power plants, Hydrothermal Resources, Hot dry rock Resources, hydrothermal geo pressure, petro-thermal and magna resources, advantages, and limitations of geo-thermal energy.

Unit 5. Wave energy & Ocean Thermal Energy

Wave Energy: Introduction: wave energy and power, wave energy devices, advantages and disadvantages, Ocean Thermal Energy: Introduction: working principle, ocean thermal energy conversion systems, status at OTEC plants, merits and demerits of OTEC plant.

Recommended Books/Reference Material

1. Araújo, K. M. (Ed.). (2023). *Routledge handbook of energy transitions*. Routledge.
2. Boutaud, B. (2022). *Energy autonomy : from the notion to the concepts*. John Wiley and Sons Inc.
3. Hossain, E., & Petrovic, S. (2021). *Renewable energy crash course : a concise introduction* (1st ed. 2021.). Springer.
4. O'Connor, J., Noble, B., & Lieuwen, T. C. (2022). *Renewable fuels : sources, conversion, and utilization* (1st ed.). Cambridge University Press.
5. Rathore, N. S., & Panwar, N. L. (2022). *Fundamentals of renewable energy*. CRC Press.
6. Singh, H., Kumar, A., & Kumar, N. (Eds.). (2022). *Renewable energy and green technology : principles and practices*. CRC Press.

11. List of Mandatory Courses

No.	Course Code	Course Title	Prereq	Cr Hrs
1.	UHQ-101	Understanding of Holy Quran-I	Nil	1
2.	ETH-103	Ethics-I	Nil	1
3.	UHQ-102	Understanding of Holy Quran-II	Nil	1
4.	ETH-104	Ethics-II	Nil	1
5.	INT-498	Internship	Nil	3
6.	CP-498	Capstone Project	Nil	3

12. Course Outlines for Mandatory Courses

Understanding of Holy Quran-I

Course Code: UHQ-101

Credit Hours: 01

Prerequisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

- Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
- Acquire a strong foundation for understanding long verses of the Quran with clarity.
- Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plurals through hundreds of Quranic sentences.
- Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath – based sentences.
- Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
- Understand at least 30 to 40 % of each page of the Holy Quran.

Course Outline:

Unit 1: Simple Quranic Words

Muallim ul Quran: Book 1: Unit: Lesson 1-19

Unit 2: Words that comes before (The simple Quranic words)

Muallim ul Quran: Book 1: Unit#2: Lesson 1-13

Unit 3: Quranic words in terms of their relationship and characteristics

Muallim ul Quran: Book 1: Unit#3: Lesson 1-10

Unit 4: Singular Pronouns

Muallim ul Quran: Book 2: Unit#4: Lesson 1-17

Unit 5: Singular pronouns & Demonstrative Pronouns

Muallim ul Quran: Book 2: Unit#5: Lesson 1-23

Unit 6: Present Tense

Muallim ul Quran: Book 3: Unit#6: Lesson 1-5

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ۲۰۲۴. جلد ۱، ۲ & ۳

Ethics-I

Course Code: ETH-103

Credit hours: 01

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to know the basics of ethics, & know how to develop an ethical approach. Also, analyze the importance of ethical and ethical values for a human being. And identify the Semitic & Non-Semitic Religions. Moreover, develop the concept of Ethics in Semitic & Non-Semitic religions. Also, analyze the similarities and differences between ethical teachings of various religions.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the concept of ethics & ethical approach.
- Analyze the difference between the concept of Ethics in Semitic and Non-Semitic religions.

Course Outline:

Unit 1: Introduction and Importance of Ethics & Basic Ethical Principles

Definition of Ethics, Importance of Ethics, Beneficence, Non-maleficence, Autonomy, Justice as basic ethical behaviors.

Unit 2: Theories of Moral Standards

Moral Standards as Law, Moral Standards as Pleasure, Moral standards as Perfection. (Theories of Various Philosophers such as Kant, Spencer, John S. Mackenzie etc)

Unit 3: The concept of Ethics in Major Religions- Christianity, Judaism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 4: The concept of Ethics in Major Religions- Hinduism & Buddhism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 5: The concept of Ethics in Major Religions- Islam

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

References/Recommended Books:

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
4. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd. UK.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوۃ المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites & Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7, 2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July 2017 from worldEconomicForum.org

5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.gloalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). "Philosophical Foundations for Global Journalism Ethics"
Journal of Mass Media Ethics:20(1)

Understanding of Holy Quran-II

Course Code: UHQ-102

Credit Hours: 01

Prerequisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

- Directly comprehend hundreds of Quranic sentences & verses.
- Understand at least 80 to 85 % of each page of the holy Quran.
- Understand common verses across different Quranic topics.
- Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
- Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
- Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Course Outline:

Unit 1: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 1: Lesson 1-9

Unit 2: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 2: Lesson 1-7

Unit 3: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 3: Lesson 1-9

Unit 4: Past Tense

Muallim ul Quran: Book 5: Unit#7: Chapter 4: Lesson 1-5

Unit 5: Past Tense & Passive Voice

Muallim ul Quran: Book 5: Unit#7: Chapter 5 - 9

Unit 6: imperative Verbs for Singulars

Muallim ul Quran: Book 6: Unit#8: Lesson 1-8

Reference Books:

- 1- بشیر، دكتور. عبید الرحمن - معلم القرآن - اسلام آباد: دار العلم، ۲۰۲۴. جلد ۳، ۴، ۵، ۶

Ethics-II

Course Code: ETH-104

Credit hours: 1

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to have better understanding of ethics in various walks of life like in workplace, in business, journalism etc. Moreover, they will be able to be familiarize with Contemporary World's Ethical Issues. And, try to develop answers about them.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the importance of ethics in their lives today.
- Identify Contemporary World's Ethical Issues.
- Create problem solving for these contemporary Ethical issues.

Course Outline:

Unit 1. Professional Ethics & Bioethics

Meaning of Work/Professional Ethics, Professional Ethics and Human Values, Elements of professional Ethics: Person attitude, Beliefs about work, Positive Attributes (honesty, integrity, dedication, commitment, responsibility, interpersonal relationship) Genetic engineering, Organ, Donation, Cloning, Head Transplant

Unit 2. Ethical Conduct in Business Ethics & it's important

Types of Business Ethics, Common Business Ethical Challenges, Conflict of interest, honesty & integrity, whistle blowing, loyalty vs truth

Unit 3. Journalism

Principles of Ethical Journalism: Truth & Accuracy, Independence, Fairness & Impartiality, Humanity, Public Accountability

Unit 4. Environmental Ethics

Core Principles of environmental ethic: Justice & sustainability, Sufficiency & compassion, Solidarity & public participation, Pollution prevention, Current issues of environmental ethics: Pollution, The depletion of natural resources, Loss of biodiversity, Destruction of ecosystem, Global climate change

Unit 5. Social Inequalities

Meaning of Social Inequalities, Issues related to social inequality, Difference in source of income, Health care, Freedom of speech, Gender inequality, Toxic workplace culture, Education, Political representation & participation

Unit 6. Social Media Ethics

Facebook, YouTube, WhatsApp, Instagram, TikTok, Snapchat, LinkedIn, X, Current Ethical issues in social media: Plagiarism, Fake news, Harassment, Photo ethics, Post without caution, inappropriate behavior privacy

References/Recommended Books:

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC

4. Robinson, D.Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books ltd.Uk.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوة المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites & Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7 ,2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.globalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World [https://www.lifepersona.com/10- ethical-problems-of-the-present-world](https://www.lifepersona.com/10-ethical-problems-of-the-present-world)
11. Ward, Stephen J.A (March 2005). “Philosophical Foundations for Global Journalism Ethics” *Journal of Mass Media Ethics*:20(1)

13. List of General Education Courses

Sr. No.	Course Code	Course Name	Pre Requisite	Credit Hours	Course Category (per HEC classification)
1.	ENG-110	Functional English	Nil	3	<i>Functional English</i>
2.	ENG-111	Expository Writing	Nil	3	<i>Expository Writing</i>
3.	PAK-103	Ideology and Constitution of Pakistan	Nil	2	<i>Ideology and Constitution of Pakistan</i>
4.	PAK-104	Pakistan Studies	Nil	2	<i>Pakistan Studies</i>
5.	ISL-101/ ETH-101	Islamic Studies/ Ethics	Nil	2	<i>Islamic Studies/Ethics</i>
6.	MTH-110	Quantitative Reasoning-I	Nil	3	<i>Quantitative Reasoning</i>
7.	STA-112	Quantitative Reasoning-II	Nil	3	<i>Quantitative Reasoning</i>
8.	MGT-108	Entrepreneurship	Nil	2	<i>Entrepreneurship</i>
9.	CCE-497	Civic and Community Engagement	Nil	2	<i>Civics and Community Engagement</i>
10.	CS-107	Application of Information and Communication Technologies	Nil	2	<i>Application of Information and Communication Technologies</i>
11.	CS-107L	Application of Information and Communication Technologies (Lab)	Nil	1	<i>Application of Information and Communication Technologies</i>
Natural Sciences Courses					
1.	ZOO-123	Cell Biology	Nil	2	<i>Natural Sciences</i>
2.	ZOO-123L	Cell Biology (Lab)	Nil	1	<i>Natural Sciences</i>
Arts and Humanities Courses					
1.	BFA-129	Arts and Humanities	Nil	2	<i>Arts and Humanities</i>
Social Sciences Courses					
1.	SOC-104	Introduction to Social Sciences	Nil	2	<i>Social Sciences</i>

14. Course Outlines for General Education Courses

Functional English

General Education Course

Course Code: ENG-110

Credit Hours: 03

Prerequisites: Nil

Objectives

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar, and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and communication aspects including professional writing, public speaking, and everyday conversation. Ensuring that students are equipped in both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with case and efficacy, making a positive impact hi their functional interactions.

Learning Outcomes

- Apply enhanced English communication skills through effective use of word choices, grammar, and sentence structure.
- Comprehend a variety of literary non-literary written and spoken texts in English.
- Effectively express information, ideas and opinions in written and spoken English.
- Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

Course Outline

Unit 1. Introduction

Ice breaking Activities. Types and modes of Communication. Intrapersonal, Intra-personal and group Communication.

Unit 2. Rules for Structure of Sentences

Types of sentences on the basis of function (Declarative, Interrogative, Imperative, Exclamatory and structure (simple, compound, complex). Synthesis of sentences. Punctuation and Spellings. Vocabulary, lexical and functional categories.

Unit 3. Concept of Time and Tense (present, past, future).

Discussion: General topics and everyday conversation. Concept of Voice: active and passive voice. Functional use of Voice in different situations.

Unit 4. Direct and Indirect Reporting.

Discussion: General topics and everyday conversation, describing things persons, places, pictures, events etc. Salutation & Greeting, Introduction, Asking and answering questions.

Unit 5. Practicing Everyday Conversation

Request and Permission, Agreement and Disagreement. Apologizing, Expressing likes and Dislikes, expressing opinion. Expressing approval, Disapproval.

Unit 6. Articulating Expression

Expressing appreciation, regret, and indifference. Expressing certainty, uncertainty, and obligation. Expressing suggestion, warning, Expressing possibility, impossibility & logical conclusion.

Unit 7. Art of Inviting

Accepting, declining invitation. Expressing & inquiring about preferences. Stating intentions and Making Plans. Giving directions. Instructing people how to do things.

Unit 8. Discussing Past and Present

Future prospects. Talking about the past.

Recommended books/ Reference material

1. Azar, B. S. (2003). *Fundamentals of English grammar*. Longman.
2. Beebe, S. A., Beebe, S. J., & Ivy, D. K. (2010). *Communication: Principles for a lifetime* (p. 483). Boston, MA: Allyn & Bacon.
3. Eastwood, J. (1994). *Oxford guide to English grammar*. Oxford University Press.
4. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.)
5. Kortmann, B. (2020). *English linguistics: essentials*. Springer Nature.
6. Langan, J. (2001). *College writing skills with readings*. New York.
7. Murphy, R. (2003). *English grammar in use*. Cambridge: Cambridge University Press.
8. Sharma, Gajendra Dutt (2023) *A Comprehensive Resource Book of Functional English*, OEP, New Delhi.
9. Thomson, A. J., & Martinet, A. V. (2015). *A practical English grammar*. New York: Oxford University Press.
10. Wren, P. C., & Martin, H. (2000). *English grammar and Composition*. New Delhi: S Chand & Company Ltd.

Expository Writing

General Education Course

Course Code: ENG-111

Credit Hours: 03

Prerequisites: Nil

Objectives

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation building prerequisite course, Functional English, this course will enhance students' basic skills of producing clear, concise, and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

Learning Outcomes

- Understand the essentials of the writing process integrating pre-working, drafting, editing and proofreading to produce well-structured essays.
- Uphold ethical practices to maintain originality in expository writing.

Course Outline

Unit 1. Introduction to Expository Writing

Understanding expository writing (definition, types, purpose and applications). Characteristics of effective expository writing (clarity, coherence and organization). Introduction to paragraph writing.

Unit 2. The Writing Process

Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.). Drafting (three stage process of drafting techniques). Revising and editing (ensuring correct grammar, Clarity, coherence, conciseness etc.). Proofreading (fine-tuning of the draft). Peer review and feedback (providing and receiving critique).

Unit 3. Essay Organization and Structure

Introduction and hook (engaging readers and introducing the topic). Thesis statement (crafting a clear and focused central idea). Body Paragraphs (topic sentences, supporting evidence and transitional devices). Conclusion (types of concluding paragraphs and leaving an impact). Ensuring cohesion and coherence (creating seamless connections between paragraphs).

Unit 4. Types of Expository Writing

Description, Illustration, Classification. Cause and effect (exploring causal relationships and outcomes). Process analysis (explaining step-by-step procedures). Comparative

analysis (analyzing similarities and differences)

Unit 5. Writing for Specific Purposes and Audiences

Different types of purposes (to inform, to analyze, to persuade, to entertain etc.). Writing for academic audiences (formality, objectivity, and academic conventions). Writing for public audiences (engaging, informative and persuasive language). Different tones and styles for specific purposes and audiences.

Unit 6. Ethical Considerations

Ensuring original writing (finding credible sources, evaluating information etc.). Proper citation and referencing (APA, MLA, or other citation styles) Integrating quotes and evidence (quoting, paraphrasing, and summarizing). Avoiding plagiarism (ethical considerations and best practices).

Recommended books/ Reference material

1. Axelrod, R. B., & Cooper, C. R. (2010). *The St. Martin's guide to writing*. Macmillan.
2. Faigley, L., Selzer, J., Enoch, J., & Wible, S. (2009). *Good reasons with contemporary arguments*. Pearson Longman.
3. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.
4. Graff, G., Birkenstein, C., & Maxwell, C. (2014). *They say, I say: The moves that matter in academic writing* (p. 245). Gildan Media Corp Book Publisher.
5. Johnson-Sheehan, R., Paine, C., & Paine, C. (2010). *Writing today*. Pearson Education India.
6. Keizer, E. (2015). *A functional discourse grammar for English*. Oxford University Press.
7. Rosenwasser, D., & Stephen, J. (2011). *Writing analytically*. Cengage Learning Press.
8. Straaijer, R. (2018). Modern English usage from Britain to America: Bryan Garner follows Henry Fowler from A Dictionary of Modern American English Usage to Garner's Modern English Usage. *English Today*, 34(4), 39-47.
9. Wachal, R. S. (2000). The Elements of Style, by William Strunk, Jr., and EB White; and A Dictionary of Modern American Usage, by Bryan A. Garner. *American speech*, 75(2), 199-207.
10. Williams, J. M., & Bizup, J. (2022). *Lessons in clarity and grace*. Pearson.

Ideology and Constitution of Pakistan

Course Code: PAK-103

Credit Hours: 02

Prerequisites: Nil

Objectives

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.

Learning Outcomes

- Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
- Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
- Explain about the guiding principles on rights and responsibilities of Pakistani citizens are enshrined in the Constitution of Pakistan 1973.

Course Outline

Unit 1. Introduction to the Ideology of Pakistan:

Definition and significance of ideology

Historical context of the creation of Pakistan (with emphasis on socio-political. Religious and cultural dynamics of British India between 1857 till 1947).

Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc.

Contributions of women and students in the freedom movement or separate homeland.

Unit 2. Two-Nation Theory:

Evolution of the Two-Nation Theory (Urdu-Hindi controversy. Partition of Bengal. Simla Deputation 1906, Allama Iqbal Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940).

Role of communalism and religious differences.

Unit 3. Introduction to the Constitution of Pakistan:

Definition and importance of a constitution.

Ideological factors that shaped the Constitution(s) of Pakistan

Overview of constitutional developments in Pakistan.

Unit 4. Constitution and State Structure

Structure of government (executive, legislature, and judiciary).

Distribution of powers between federal and provincial governments.

18th Amendment and its impact of federalism.

Unit 5. Fundamental Rights, Principles of Policy and Responsibilities

Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles R-28)

Overview of Principles of Policy (Articles 29-40).

Responsibilities of the Pakistani citizen.

Unit 6 Constitutional Amendments:

Procedures for amending the Constitution

Notable constitutional amendments and their implications

Recommended Books/Reference Material

1. Ahmed, A. S. (1997). *Jinnah, Pakistan and Islamic Identity: The Search for Saladin*.
2. Aziz, K. K. (2002). *The Making of Pakistan: A Study of Nationalism*.
3. Choudhury, G. W. (1960). *Constitutional Development in Pakistan*.
4. Choudhury, G. W. (1969). *Constitution-Making in Pakistan: The Dynamics of Political*.
5. Cohen, S. P. (2004). *The Idea of Pakistan*.
6. Hussain, M. (2020). *The Parliament of Pakistan*.
7. Iqbal, J. (2005). *Ideology of Pakistan*.
8. Jalal, A. (2014). *The Struggle for Pakistan: A Muslim Homeland and Global Politics*.
9. Khan, H. (2009). *Constitutional and Political Development of Pakistan*.
10. Mahmood, S. (2003). *Pakistan: Political Roots and Development*.
11. Mujahid, S. U. (2001). *Ideology of Pakistan*.
12. Qureshi, I. H. (1965). *The Struggle for Pakistan*.
13. Sayeed, K. B. (1960). *Pakistan: The Formative Phase*.
14. Talbot, I. (2015). *Pakistan: A New History*.
15. *The Constitution of Pakistan 1973*.
16. Ziring, L. (2000). *Pakistan in the Twentieth Century: A Political History*.

Pakistan Studies

Course Code: PAK-104

Credit Hours: 02

Prerequisites: Nil

Course Description

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

Course Learning Outcomes

By the end of this course, students will be able to:

- Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
- Understand the society and culture of Pakistan.
- Understand and explain the socio-economic developments in Pakistan.
- Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

Course Outline

Unit 1. Introduction to Pakistan

Geographical location and significance. Historical background: Ancient civilizations in the region. Factors leading to the creation of Pakistan.

Unit 2. Political History of Pakistan

Formative phase. Military interventions and democratic transitions.

Unit 3. Geography of Pakistan

Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas. River systems: Indus River and its tributaries. Climatic regions of Pakistan.

Unit 4. Society and Culture of Pakistan

Socio-cultural diversity. Languages and literature of Pakistan.

Unit 5. Economic Development of Pakistan

Agriculture and industrial sectors of Pakistan. Economic challenges of Pakistan.

Unit 6. Contemporary Issues

Foreign relations of Pakistan, Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

Suggested Instructional/Reading Materials

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan

7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by Ian Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir
11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi
15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan
16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain
20. "Issues in Pakistan's Economy" by S. Zaidi

Islamic Studies

Course Code: ISL-101

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will be able to demonstrate enhanced knowledge of islamic fundamentals, beliefs, practices, historical development, spiritual values and ethical principles. Describe basic sources of islamic law and their application in daily life. Also, identify and discuss contemporary issues being faced by the muslim world including social challenges, gender role and interfaith dialogue.

Learning Outcomes

- Evaluate and discuss their understanding about the beliefs, history and Ethical values of Islam.
- Be able to apply and relate the Articles of faith in their life according to present world.
- Be able to analyze the importance of Quran and Sunnah in their life and also to refute many relating misconceptions
- Engage in Discussions and write about Contemporary issues specifically related to Women.

Course Outline:

Unit 1. Introduction to Islam

Definition of Islam and its core Beliefs (Tawheed, Akhirat and Risalat), Pillars of Islam and their significance (Tawheed, Prayers, Fasting, Zakat & Hajj), The Holy Quran (Introduction, Revelation & Compilation), Sunnah & Hadith (Introduction, Revelation & Compilation).

Unit 2. Seerah of the Holy Prophet PBUH

Life of Prophet PBUH in Makkah, Life of Holy Prophet PBUH in Medina, Diverse roles of Holy Prophet PBUH (individual, leader, peacemaker, educator etc).

Unit 3. Islamic History and Civilization

World before Islam, The Rashidun Caliphate and its expansion, Contributions of Muslim Scientists and Philosophers.

Unit 4. Islamic Jurisprudence

Fundamental sources of Islamic Jurisprudence, Major Schools of Islamic Jurisprudence, Significance & principle of Ijtihaad.

Unit 5. Family & Society in Islam

Status and Rights of Women in Islam, Marriage, Family & Gender roles in Muslim Society, Family values and Structure in Muslim Society.

Unit 6. Islam & Modern world

Relevance of Islam in Modern World. (Islamophobia, Interfaith dialogue & Multiculturalism), Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books/Reference Material

1. Ahmed, Dr. A. (1996). *Women & Social Justice: An Islamic Paradigm*, The Islamic Foundation UK
2. Ahmed, K. (1971) *Islami Nazria e Hayat*, Karachi University press.
3. Ahmed, K. (1980). *Islam, Its meaning & message*, The Islamic Foundation UK.
4. Al-Mubarikpuri, M. S. (2002), *Al Raheeq ul Makhtoom (The Sealed Nector)*, Dar ul Salam.
5. Al-Suhaym, Dr. M.B., A. (2006) *Islam, Its foundation & concepts*, Darussalam
6. An Introduction to Islamic Theology by John Renard.
7. Bokhari, A.S, Zafar, M.D., Prof. Shakir, A.S. (2021). *A textbook of Islamic Education*, Akram Printing Press, Lahore.
8. Hussain, M. *The Five Pillars of Islam: A Framework for Islamic Values and Character building*, Kube Publishing, The Islamic Foundation UK
9. Maududi, Abul A. (2008). *Islamic Civilization Foundations, Beliefs & Principles*, Kube Publishing, Islamic Foundation UK
10. Maududi, Abul. A. (2007). *Towards understanding Islam*, The Islamic foundation UK
11. Phillip, Dr. A. A., B. (2018) *Islamic Studies*, International Islamic Publishing House.
12. Prof. Dr. Chaudary, M.N., Prof. Malik, M.A (2022). *Tafheem e Islamiyat*, Qureshi Brothers Publishers, Lahore.

Ethics

Course Code: ETH-101

Credit Hours: 02

Prerequisites: Nil

Objectives:

Upon successful completion of the course, students will be able to know the basics of Ethics & Morality and develop Ethical approach, Identify the concept of Ethics in Different Religions & Relate the ethical values with their lives business ethics, journalism ethics etc.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the meaning of Ethics and Morality.
- Analyze the Similarities and Differences between ethical teachings of various religions.
- Develop sense of belongingness to the ethical values as a student, being member of the society etc.

Course Outline:

Unit 1. Meaning and Scope of Ethics

Meaning and Definition of Ethics and Morality, Difference between Ethics and Morality
Relation of Ethics with: Religion, Science, Law.

Unit 2. Historical development of Morality

Instinctive Moral Life, Customary Morality. Reflective Morality.

Unit 3. Moral Theories, Moral Ethics and Society

Hedonism (Mill), Intuitionism (Butler), Kant's Moral Theory, Freedom and Responsibility, Tolerance, Justice, Punishment.

Unit 4. Moral Teaching of Major Religions

Judaism, Christianity, Islam, Islam and Minorities.

Unit 5. Professional Ethics

Medical Ethics, Ethics of student, Ethics of teacher, Business Ethics.

Recommended Books/ Reference Material:

1. R. Shafer-Landau. (2020). *The Fundamentals of Ethics*, (5th ed.).
2. S. Blackburn. (2021). *Ethics: A Very Short Introduction (Very Short Introductions)* (2nd ed.).
3. S. Liataud, L. Sweetingham. (2022). *The Power of Ethics: How to Make Good Choices in a Complicated World*.
4. S. M. Cahn, P. Markie. (2019). *Ethics: History, Theory, and Contemporary Issues*, (7^h ed.).

Quantitative Reasoning-I

Course Code: MTH-110

Credit Hours: 03

Prerequisites: Nil

Objectives

Quantitative Reasoning-I is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

Learning Outcomes

By the end of this course,

- The students shall have fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately.
- Understanding of fundamental mathematical concepts. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

Course Outline

Unit1. Numerical Literacy

Number system and basic arithmetic operations. Units and their conversions, dimensions, area, perimeter, and volume. Rates, ratios, proportions, and percentages. Types and sources of data; Measurement scales. Tabular and graphical presentation of data. Quantitative reasoning exercises using number knowledge.

Unit 2. Fundamental Mathematical Concepts

Basics of geometry (lines, angles, circles, polygons etc. Relations, functions, and their graphs. Exponents, factoring and simplifying algebraic expressions. Algebraic and graphical solutions of linear and quadratic equations and inequalities. Quantitative reasoning exercises using fundamental mathematical concepts.

Unit 3. Mathematical Modeling and Analyses

Introduction to deterministic models. Use of linear functions for modeling in real-world situations. Modeling with the system of linear equations and their solutions. Elementary introduction to derivatives in mathematical modeling. Linear and exponential growth and decay models. Quantitative reasoning exercises using mathematical modeling.

Unit 4. Logic, Logical and Critical Reasoning

Introduction and importance of logic. Inductive, deductive and abductive approaches of reasoning. Propositions, arguments (valid, invalid), logical connectives, truth tables and propositional equivalences. Logical fallacies. Venn Diagrams. Predicates and quantifiers. Quantitative reasoning exercises using logical reasoning concepts and techniques.

Recommended Books/Reference Books

1. Bennett, J., & Briggs, W. (2019). *Using & understanding mathematics: quantitative reasoning approach*. Pearson.
2. Mesquita, E.B., and Fowler, A. (2021). *Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis*. Princeton University Press.
3. Rosen, K. H. (2007). *Discrete mathematics and its applications*. The McGraw Hill Companies.
4. Schröder, B. (2010). *Fundamentals of Mathematics*. Wiley.
5. Zaslow, E. (2020). *Quantitative Reasoning: Thinking in Numbers*. Cambridge University Press.

Quantitative Reasoning-II

BS-Statistics

Course Code: STA-112

Credit Hours: 03

Prerequisites: Nil

Objectives

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of other sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. The course also focuses on basic principles of probability and distributions, regression and correlation analysis, estimation and testing of hypothesis. It will prepare students to apply the quantitative reasoning skills in solving quantitative problems which they will experience in their practical lives.

Learning Outcomes

- Student will understand the basic statistical concepts and have basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts and equation etc.
- Understand basic quantitative modeling and analyses.
- Ability to critically evaluate quantitative information to make evidence based decision through appropriate statistical tools.

Course Outline

Unit 1. Introduction of Statistic and Data Condensation

Types and sources of data. Measurement scales. Population and sample. Tabular and graphical presentation of data. Quantitative reasoning exercises using fundamental statistical concepts.

Unit 2. Measure of Central Tendency and Dispersion

Measure of central tendency. Measure of dispersion. Data interpretation. Quantitative reasoning exercises using statistical concepts.

Unit 3. Probability and Probability Distributions

Basic probability theory. Rules of counting (multiplicative, permutation, combinations). Introduction to random variables and their probability distributions. Quantitative reasoning exercises using probability theories and distribution concepts.

Unit 4. Regression and Correlation Analysis

Introduction to probabilistic models. Bivariate analysis. Scatter plots. Simple linear regression model. Correlation analysis. Quantitative reasoning exercises using statistical modelling.

Unit 5. Estimation and Testing of Hypothesis

Basics of estimation and confidence interval. Testing of Hypothesis (z-test; t-test). Statistical inference in decision making. Quantitative reasoning exercises using estimation and Statistical inference concepts and techniques.

Recommended Books/Reference Material

1. Chaudhry S.M. & Kamal. S. (2018). *Introduction to Statistical Theory Part I*. Ilmi Kitab Khana Lahore, Pakistan.
2. Chaudhry S.M. & Kamal. S. (2018). *Introduction to Statistical Theory Part II*. Ilmi Kitab Khana Lahore, Pakistan.
3. Hogg, R., Mckean, J. & Craig, A. (2021). *Introduction to Mathematical Statistics*, (8th ed.). Pearson, Boston.
4. Mendenhall, W., Beaver, R. J., & Beaver, B. M. (2012). *Introduction to Probability and Statistics*. Cengage Learning.
5. Mood, A.M., Graybill, F.A. & Boes, D.C. (1974). *Introduction to the Theory of Statistics* (3rd ed.). McGraw Hill, New York.
6. Moore, D. S., McCabe, G.P. & Craig, B. A. (2021). *Introduction to the Practice of Statistics*, (10th ed.). WH Freeman, New York.
7. Walpole, R. E. (2002). *Introduction to Statistics*, (7th ed.). Macmillan publishing company, New York.
8. Walpole, R.E., Myers, R.H. & Myers, S.L. (1998). *Probability and Statistics for Engineers and Scientist* (6th ed.). Prentice Hall, New York.

Entrepreneurship

BBA

Course Code: MGT-108

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is basically designed to enhance entrepreneurial attitude among students by imparting confidence in them, by having them hands on experience of small entrepreneurial activity. This will contribute towards economic development of Pakistan, as these students will soon be in the market and will be contributing in the economy in a better way through entrepreneurial activities.

Learning Outcomes

After studying this course, the student will be able to:

- Better understand themselves and their suitability to be an entrepreneur.
- Better understand the marketing and sales concepts and strategies, engaging customers, building the brand, and driving revenues.

Unit 1. The Challenge of Entrepreneurship

The World of the Entrepreneur. What is an Entrepreneur? The Benefits of Entrepreneurship. The Potential Drawbacks of Entrepreneurship. The Power of “Small” Business. Putting Failure into Perspective. The Ten Deadly Mistakes of Entrepreneurship. How to Avoid the Pitfalls. Creativity, Innovation, and Entrepreneurship. Creativity – Essential to Survival. Creative Thinking. Barriers to Creativity. The Creative Process. Techniques for Improving the Creative Process.

Unit 2. Designing a Competitive Business Model and Building a Solid Strategic Plan

Building a Competitive Advantage. The Strategic Management Process. Formulate strategic options and select the appropriate strategies. The Balanced Scorecard

Unit 3. Conducting a Feasibility Analysis, Forms of Business Ownership and Franchising

Conducting a Feasibility Analysis. Why Develop a Business Plan? The Elements of a Business Plan. The Sole Proprietorship. Other Forms of Ownership. Types of Franchises. The Benefits of Buying a Franchise. The Drawbacks of Buying a Franchise. Franchising and the Law. The Right Way to Buy a Franchise. Trends Shaping Franchising

Unit 4. Building a Powerful Marketing Plan

Building a Guerrilla Marketing Plan. Pinpointing the Target Market. Determining Customer Needs and Wants Through Market Research. Plotting a Guerrilla Marketing Strategy: How to Build a Competitive Edge

Unit 5. Creating a Successful Financial Plan

Basic Financial Statements. Projected Financial Statements. Ratio Analysis. Interpreting Business Ratios. Breakeven Analysis

Unit 6. Sources of Financing: Debt and Equity Phase Discussion

Planning for Capital Needs. Sources of Equity Financing. Corporate Venture Capital. Sources of Debt Capital. Federally Sponsored Programs. Small Business Administration (SBA)

Unit 7. Choosing the Right Location and Layout

Location: A Source of Competitive Advantage. Location Criteria for Retailers and Service Businesses. Location Options for Retail and Service Businesses. The Location Decision for Manufacturers. Layout and Design Considerations. Layout: Maximizing Revenues, Increasing Efficiency, or Reducing Cost

Recommended Books/ Reference Material

1. "Essentials of entrepreneurship and small business management" by Scarborough, Norman M & Jefferey R.Cornwall.
2. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.

Civic and Community Engagement

Course Code: CCE-497

Credit Hours: 02

Prerequisites: Nil

Objectives

This course is designed to provide students with fundamental knowledge about civics, citizenship and community engagement. In this course the students will learn about the essential of civil society, government, civic responsibilities, inclusivity and effective ways to participate in shaping the society which will help them apply the theoretical knowledge to the real-world situation to make a positive impact on their communities.

Learning Outcomes

By the end of this course, student will be able to:

- Demonstrate fundamental understanding of civics, government, citizenship and civil society.
- Understand the concept of community and recognize the significance of community engagement for individuals and groups.
- Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

Course Outline

Unit 1. Civics and Citizenship

Concepts of civics, citizenship, and civic engagement. Foundations of modern society and citizenship. Types of citizenship: active, participatory, digital etc.

Unit 2. State, Government and Civil Society

Structure and function of government in Pakistan. The relationship between democracy and civil society. Right to vote and importance of political participation and representation.

Unit 3. Rights and Responsibilities

Overview of fundamental rights and liberties of citizens under constitution of Pakistan 1973. Civic responsibilities and duties. Ethical consideration in civic engagement (accountability, non-violence, peaceful dialogue, civility etc.).

Unit 4. Community Engagement

Concept, nature and characteristics of community. Community development and social cohesion. Approaches to effective community engagement. Case studies of successful community driven initiatives.

Unit 5. Advocacy and Activism

Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements.

Unit 6. Digital Citizenship and Technology

The use of digital platform for civic engagement. Cyber ethics and responsible use of social media. Digital divides and disparities (access, usage, socio-economic, geographic etc.) and their impact on citizenship.

Unit 7. Diversity, Inclusion and Social Justice

Understanding diversity in society (ethnic, cultural, economic, political etc.). Youth, women and minorities engagement in social development. Addressing social inequalities and injustices in Pakistan. Promoting inclusive citizenship and equal rights for social harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

Apart of the overall learning requirements, the course may have one or a combination of the following practical activities

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews or multimedia presentations that captured the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Student can organize a community event or workshop that addresses a specific issue or foster community interaction. This could be a health fair, environmental cleanup, cultural festival or educational workshop
3. **Service Learning:** Student can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time, and skills to address a particular community need, such as tutoring, mentoring or supporting vulnerable population.
4. **Cultural Exchange Activities:** Student can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances and presentations that promote cross cultural understanding.

Recommended Books/Reference Material

1. Džankić, J., & VINK, M. P. (2022). Citizenship & migration.
2. Kymlicka, W. and Norman, W. (2010). *Citizenship in Diverse Societies*. University Press, United Kingdom.
3. Mackert, J., & Turner, B. S. (2017). The Transformation of Citizenship, Volume 2. Boundaries of Inclusion and Exclusion.
4. Mattson, K. (2017). *Digital Citizenship in Action: Empowering Students to Engage in Online Communities*. : International Society for Technology in Education, United Kingdom.
5. McGraw-Hill Education, (2009). *Civics Today: Citizenship, Economics, & You*, Student Edition. United States.
6. Weinstock, D. (2017). Citizenship and Cultural Diversity. The Oxford Handbook of Citizenship.
7. Youniss, J. and Levine, J. (2009). *Engaging Young People in Civic Life*. Vanderbilt University Press, Ukraine.

Application of Information and Communication Technologies

BS-CS

Course Code: CS-107

Credit Hours: 02

Prerequisites: Nil

Objectives

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline

Unit 1. Technology

Types of Computers, Mobile & Game Devices, Data and Information, The Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy, Health Concerns, Environmental Issues, Programs and Apps, Operating Systems, Applications, Installing and Running Programs, Developing Programs and Apps, Communications and Networks, Wired and Wireless Communications, Networks, Technology Uses, Government, Finance, Retail, Entertainment, Health Care, Science, Travel, Publishing, Manufacturing, Technology Users.

Unit 2. Online Web

The Internet, Websites and Media, The Internet, Evolution of the Internet, connecting to the Internet, Internet Service Providers, How Data Travels the Internet, IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit 3. Evaluating Computers and Mobile Devices

Mobile Computers and Desktops, Laptops, Tab and Other Mobile Computers, Handheld Computers, Desktops and All-in-Ones, Servers, Terminals, Point-of-Sale Terminals,

Wearable Devices, Game Devices, Embedded Computers, Inside the Case, The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services, Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit 4. Programs and Apps

Role of the Operating System, Obtaining Software, Installing Software, Categories of Programs and Apps, Multimedia and Interest Applications, Communications Applications, File, Disk, and System Management Tools.

Unit 5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure, Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering, What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended books/reference material:

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). *Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach*. Cengage Learning.
2. Hafez, K., Skinner, A., & Grüne, A. (2022). *Foundations of Global Communication: A Conceptual Handbook*. Routledge.
3. Hawkrigde, D. (2022). *New information technology in education*. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). *Managing and using information systems: A strategic approach*. John Wiley & Sons.

Application of Information and Communication Technologies (Lab)

BS-CS

Course Code: CS-107L

Credit Hours: 01

Prerequisites: Nil

Objectives

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline

Unit 1. Technology

Introduction to the lab equipment and SOPs of the labs. Introduction to computer hardware and system information. Introduction to the Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy.

Unit 2. Online Web

IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit 3. Evaluating Computers and Mobile Devices

Inside world: The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards,

USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit 4. Programs and Apps

File, Disk, and System Management Tools. MS office

Unit 5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure. Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended books/reference material:

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). *Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach*. Cengage Learning.
2. Hafez, K., Skinner, A., & Grüne, A. (2022). *Foundations of Global Communication: A Conceptual Handbook*. Routledge.
3. Hawkrigde, D. (2022). *New information technology in education*. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). *Managing and using information systems: A strategic approach*. John Wiley & Sons.

Arts and Humanities

BS-Fine Arts

Course Code: BFA-129

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will recognize the varying historical, social, political, and economic conditions that shape human action. They will identify how individuals relate to or diverge from particular social norms through the creation of artistic and expressive forms. Students will examine “texts” in any language or structure, and/or art forms in one or more media. They will account for how different worldviews and challenges are expressed in the arts and humanities as a product of interaction among diverse groups.

Learning Outcomes

- Students will gain knowledge in the Arts and Humanities
- Students will engage in complex analysis and reasoning.
- Students will demonstrate media and information literacy.
- Students will communicate effectively.

Course Outline

Unit 1. Criticism, Appreciation and History

What is criticism? What is appreciation? What is History? Comparison between the three. Defining art by different forms of arts: Visual, Performing, Minor, Applied, Plastic Arts, Tiles, Cave art, Music, Dance, Architecture, Painting, Sculpture, Minor arts, literature, etc. Stressing on visual arts. Assignment: Mini sculptures, designing tiles, jewelry making, mosaic.

Unit 2. Appreciation, Meaning of Humanities, Background of Arts

Subject, Function, Medium, Organization, Style and Judgment. Subject: What is it about? Function: what is it for? Medium, very essential: what is it made of? Organization: how is it put together? Style: what is the personality, the individuality of the work? Judgment: how effective is it? Experience, authority, sincerity, humanity. Subject: subject in music, art and nature, art and history, way of presenting the subjects, explanation of the subject, symbol, the irrational, sources of the subject (nature, mythology/religion, history and genre).

Unit 3. Function / Medium

Artist and his medium, techniques, judgment in relation to medium. Organization Plans: (typical, symmetrical, pyramidal, vertical, radical, compound plans), examples from visual arts. Centre of interest: organization of the visual arts, the elements of visual arts.

Unit 4. Art and Culture

Art and Beauty. Art and Religion. Art and Nature. Art and History. Art as an Idea.

Unit 5. Style/ Judgment

Definition, a few characteristics of style, two approaches to study styles, historical style, realism / judgment. Judgment: Sincerity and Sentimentality The problem of judgment. Scope: how much the artist is trying to do? What has he attempted? Levels of meanings. Truth. Magnitude: growth in judgment. Assignment: Working with elements of art.

Recommended Books/Reference Material

1. Davies. (2018) *Definitions of Art*. Cornell University Press, New York.
2. Edwards. (2023). *Ancient Civilizations of History - Trivia Adventures*. United States.
3. Nguyen. (2023). *The Art of Creating:How to Create Art that Transforms Yourself and the World*. One Satori Publishing, United States.
4. Sporre, D. (2015). *Perceiving the Arts: An Introduction to Humanities*. New Jersey, Prentice Hall.

Introduction to Social Sciences

BS- Sociology

Course Code: SOC-104

Credit Hours: 02

Pre-requisite: Nil

Objectives:

Introduction to Social Sciences offers a comprehensive overview of the various disciplines within social sciences, exploring their origins, scope, methodologies, applications, and interconnectedness. Students will be introduced to anthropology, sociology, psychology, political science, economics, geography, and history, with an emphasis on their relevance to contemporary Pakistani society. The course encourages critical thinking, interdisciplinary understanding, and the application of social sciences in real-world contexts.

Learning Outcomes

Upon completion of this course, students will be able to:

- Understand the origins and development of social sciences as distinct fields of study.
- Recognize the scope, methodologies, and principles of various social science disciplines.
- Analyze social phenomena from interdisciplinary perspectives.
- Apply social science concepts to understand and address issues relevant to Pakistani society.
- Engage in critical discussions, research, and ethical considerations within social sciences.

Course Outline

- | | |
|----------------|---|
| Unit 1. | <u>Introduction to Social Science</u>
Definition and Importance of Social Sciences, Historical Development and Interconnectedness |
| Unit 2. | <u>Anthropology</u>
Scope, Methods, and Key Concepts, Cultural and Biological Anthropology |
| Unit 3. | <u>Sociology</u>
Origin and Scope of Sociology, Key Concepts, Sociological Imagination |
| Unit 4. | <u>Psychology</u>
Introduction to Psychology and its Branches, Human Behavior and Mental Processes |
| Unit 5. | <u>Political Science</u>
Understanding Political Systems and Governance, Politics and International Relations |
| Unit 6. | <u>Social Sciences in Pakistani Society</u>
Application of Social Sciences in Pakistani Context, Social Issues, Policies, and Cultural Insights |
| Unit 7. | <u>Research Methods in Social Sciences</u>
Quantitative and Qualitative Research. Research Ethics |
| Unit 8. | <u>Interdisciplinary Approaches and Future Trends</u>
Integration of Social Science Disciplines, Emerging Trends and Future Challenges |

Recommended Books/Reference Material

1. Colander, D., & Hunt, E. (2022). *Social science: An introduction to the study of society*. Routledge.
2. Gerring, J. (2011). *Social science methodology: A unified framework*. Cambridge University Press.
3. Habermas, J. (2015). *On the logic of the social sciences*. John Wiley & Sons.
4. Sharpes D. K. (2009). *The evolution of the social sciences*. Lexington Books.
5. Williams, M. (2012). *Science and social science: An introduction*. Routledge.

List of Natural Sciences Courses

No.	Course Code	Course Title	Prerequisites	Cr. Hrs	HEC Category
1	ZOO-123	Cell Biology	Nil	2	<i>Natural Sciences</i>
2	ZOO-123L	Cell Biology (Lab)	Nil	1	<i>Natural Sciences</i>

Course Outlines of Natural Sciences Courses

Cell Biology

BS-Zoology

Course Code: ZOO-123

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will acquire knowledge about the basic concepts of cell biology. They will learn about the cellular structure, composition of the organelles, cell growth and cellular division. They will know about how macromolecules and organelles govern the dynamic organization, function of living cells.

Learning Outcomes

- Students will acquire the basic concepts of cell biology.
- Students will understand the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.
- Students will have the ability to understand the role of macromolecules regulating cellular processes.

Course Outline

Unit 1. Cell Structure and Function

Cell theory. Comparison of plant and animal cells. Comparison of prokaryotic and eukaryotic cells. Structural models of cell membrane. Chemical composition of cell membrane and its function

Unit 2. Cell Organelles

Endoplasmic reticulum. Golgi Bodies. Mitochondria. Lysosomes. Peroxisomes. Ribosome

Unit 3. Nucleus

Structure and function. Nuclear membrane. Chromatin

Unit 4. Cytoskeleton

Structure and types. Functions of cytoskeleton

Unit 5. Cellular Transport

Diffusion and osmosis. Facilitated and active transport. Endocytosis and exocytosis

Unit 6. Cellular Reproduction

Cell cycle. Mitosis. Meiosis

Recommended Books/Reference Material

1. Alberts. (2023). *Essential Cell Biology*. W. W. Norton & Company.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. (2017). *Molecular biology of the cell*. 6th Edition. Garland science.
3. Chandar D.N., Viselli, D.S.M. (2020). *Cell and Molecular Biology*. 2nd Edition. LWW.

4. De Robertis, E. D. P. (2017). *Cell and Molecular Biology*. 8th edition, Lea & Febiger, New York.
5. Geoffrey M.C., Robert E.H. (2007). *The cell: A Molecular Approach*. Sinauer Associates, INC.
6. Karp, J. (2005). *Cell and Molecular Biology, Concepts and Experiments*. Jhon Wiley and Sons, INC.
7. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. C. (2016). *Molecular Cell Biology*. Macmillan Higher Education.
8. Miller, S.A. and Harley, J.B. (2014). *Zoology*. 12th Ed. (International), Singapore: McGraw-Hill
9. Stanger B. (2023). *From One Cell: A Journey into Life's Origins and the Future of Medicine*. W. W. Norton & Company. UK

Cell Biology (Lab)

BS-Zoology

Course Code: ZOO-123L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire knowledge about the basic staining techniques. They will learn about the identification of cell organelles. They will know about the different stages of mitosis and meiosis.

Learning Outcomes

- Students will be able to identify the prepared slides of different cell organelles.
- Students will be able to know the techniques of preparation of whole mount.
- Students will understand the different stages of cell cycle

Course Outline

1. Study of microscope.
2. Study of staining techniques (Gram staining).
3. Study of prepared slides of cell organelles.
4. Preparation of temporary whole mount.
5. Preparation of permanent whole mount.
6. Squash preparation of onion root tip for mitotic stages.
7. Study of mitotic and meiotic stages with the help of prepared slides.

Recommended Books/Reference Material

1. Alberts. (2023). *Essential Cell Biology*. W. W. Norton & Company.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. (2017). *Molecular biology of the cell*. 6th Edition. Garland science.
3. Chandar D.N., Viselli, D.S.M. (2020). *Cell and Molecular Biology*. 2nd Edition. LWW.
4. De Robertis, E. D. P. (2017). *Cell and Molecular Biology*. 8th edition, Lea & Febiger, New York.
5. Geoffrey M.C., Robert E.H. (2007). *The cell: A Molecular Approach*. Sinauer Associates, INC.
6. Karp, J. (2005). *Cell and Molecular Biology, Concepts and Experiments*. Jhon Wiley and Sons, INC.
7. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. C. (2016). *Molecular Cell Biology*. Macmillan Higher Education.
8. Miller, S.A. and Harley, J.B. (2014). *Zoology*. 12th Ed. (International), Singapore: McGraw-Hill.
9. Stanger B. (2023). *From One Cell: A Journey into Life's Origins and the Future of Medicine*. W. W. Norton & Company. UK.

15. Pool of Interdisciplinary Courses

Course Code	Course Title	Course Type	Prereq.	Cr. Hr.
MTH-111	Elementary Linear Algebra	Interdisciplinary/Allied	Nil	3
PHY-321	Environmental Physics	Interdisciplinary/Allied	Nil	3
PHY-322	Scientific Inquiry and Research Methods	Interdisciplinary/Allied	Nil	3
PHY-327	Computational Physics	Interdisciplinary/Allied	Nil	2
PHY-327L	Computational Physics (Lab)	Interdisciplinary/Allied	Nil	1
PHY-410	Medical Physics	Interdisciplinary/Allied	Nil	3
PHY-430	Artificial Intelligence in Physics	Interdisciplinary/Allied	Nil	2
PHY-430L	Artificial Intelligence in Physics (Lab)	Interdisciplinary/Allied	Nil	1
CS-206	Artificial Intelligence	Interdisciplinary/Allied	Nil	2
CS-206L	Artificial Intelligence (Lab)	Interdisciplinary/Allied	Nil	1
CS-414	Introduction to Data Science	Interdisciplinary/Allied	Nil	2
CS-414L	Introduction to Data Science (Lab)	Interdisciplinary/Allied	Nil	1

16. Course Outlines for Interdisciplinary Courses

Elementary Linear Algebra

BS-Mathematics

Course Code:MTH-111

Credit Hours: 03

Prerequisite: Nil

Objectives

Students should be familiar with the basics of Linear algebra which is a branch of mathematics that deals mainly with properties of matrices, vector spaces and linear transformations.

Learning Outcomes

- The students must be familiar with the properties of matrices in solving the linear equations and how these are useful in linear transformations between the vector spaces.
- The students can use this skill set in different fields of computer sciences and information technology.

Course Outline

Unit 1. Algebra of Matrices

Matrices, squares of Matrices, trace, powers of matrices, polynomials in matrices, invertible matrices. Orthogonal matrix, normal matrix. Hermitian matrix, unitary matrix, (Complex). Normal Matrix. Block matrices.

Unit 2. System of Linear Equations

System of linear equations and its solutions. Equivalent systems. Elementary operations echelon and reduced echelon form, inverse of matrix using elementary row operations, Solution of linear systems. Gauss-Jordan method and Gaussian elimination method.

Unit 3. Determinants

Determinants of matrix of order two and three, Definition of determinants of the same order, computing of determinants. Definition of higher order determinants, properties, expansion and applications of determinants.

Unit 4. Vector Spaces, Eigen values and Eigenvectors

Vector's basic definitions, Vector addition and scalar multiplication. Dot and cross product. Orthogonality. Definition and examples of vector spaces, subspaces. Linear combination spanning. Linear independence and dependence. Eigen values and eigenvectors. Diagonalization.

Unit 5. Inner Product Spaces

Definition and examples. Properties and Projection. Angle and orthogonality. Cauchy inequality.

Recommended Books/Reference Material

1. Anton, H., & Rorres, C. (2013). *Elementary linear algebra: applications version*. John Wiley & Sons.
2. Lyche, T. (2020). *Numerical Linear Algebra and Matrix Factorizations*. Springer Nature

3. Rorres, C. (2006). *Elementary linear algebra*. Mississauga, Ont.: Wiley.
4. Strang, G. (2022). *Introduction to linear algebra*. Wellesley-Cambridge Press.
5. Shapiro, H. (2015). *Linear algebra and matrices*. AMS, Providence, Rhode Island.

Environmental Physics

BS-Physics

Course Code: PHY-321

Credit Hours: 03

Prerequisites: Nil

Objectives

To get an understanding of environmental crisis and problems and to enable students to discover more techniques to save the environment.

Learning Outcomes

- Analyze physical principles underlying environmental processes and phenomena.
- Apply concepts of energy, radiation, and thermodynamics to environmental systems.
- Evaluate the impact of human activities on the environment using physical models.

Course Outline

Unit 1. Introduction to the Essentials of Environmental Physics

The Economic System, Living in Green House, Enjoying the Sun, Transport of Matter, Energy and Momentum, Social and Political Context.

Unit 2. Basic Environmental Spectroscopy

Black Body Radiation, The Emission Spectrum of Sun, The Transition Electric Dipole Moment, The Einstein Coefficients, Lambert-Beer's Law, The Spectroscopy of Bi-Molecules, Solar UV and Life, The Ozone Filter.

Unit 3. The Global Climate

Energy Balance, (Zero-Dimensional Greenhouse Model), Elements of Weather and Climate, Climate Variations and Modeling.

Unit 4. Transport of Pollutants

Diffusion, Flow in Reverse, Ground Water, Flow Equations of Fluid Dynamics, Turbulence Diffusion, Gaussian Plumes in Air, Turbulent Jets and Planes.

Unit 5. Noise

Basic Acoustics, Human Perceptions and Noise Criteria, Reducing the Transmission of Sound, Active Control of Sound.

Unit 6. Radiation

General Laws of Radiation, Natural Radiation, Interaction of Electromagnetic Radiation and Plants, Utilization of Photo Synthetically Active Radiation.

Unit 7. Atmosphere and Climate

Structure of the atmosphere, Vertical Profiles in the Lower Layers of the Atmosphere, Atmosphere Circulation, Clouds and Precipitation, The Atmospheric Greenhouse Effect.

Recommended Books/Reference Material

1. Blake D. & Robson R. (2008). *Physical principles of meteorology and environmental physics : global synoptic and micro scales*. World Scientific.
2. Bolivar N. (2021). *Environmental physics*. Arcler Press.
3. Monteith J. L. (2013). *Principles of environmental physics* (4th ed.). Academic Press.
4. Rodrigues A. Sardinha R. A. & Pita G. (2021). *Fundamental principles of environmental physics*. Springer.
5. Vallero D. A. (2022). *Applications and calculations in environmental physics*. AIP Publishing

Scientific Inquiry and Research Methods

BS-Physics

Course Code: PHY-322

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will acquire understanding about various types of research studies, designing a research problem, analysis and interpretation of data to conduct an independent research study.

Learning Outcomes

- Explaining the principles of scientific inquiry and research design.
- Analyze and interpret data using appropriate research methodologies.
- Apply research methods to conduct independent research studies.

Course Outline

Unit 1. Research Process

Knowledge and Research, Scientific Method, Theoretical Foundation of Scientific Method, Steps in Scientific Method, Assumptions, Use of Scientific Method in Sciences, Characteristics of Scientific Studies, Classification of Research by Purpose, Basic Research, Applied Research, Action Research, Classification of Research by Strategy, Quantitative Research, Qualitative Research

Unit 2. Research Problem

Selection and statement, Sources, Criteria Selection, Statement, Development Conceptual Framework, Review of Related Literature, Organizing and citation, Formulation and statement of hypotheses, Definition and purpose, Types of hypotheses, Stating the Hypotheses, Testing the Hypotheses

Unit 3. Quantitative Research

Surveys, Questionnaire, Characteristics and uses of Surveys, Types of Surveys by Method, One shot or cross sectional survey, Successive independent sample survey, Panel or longitudinal, Types of Surveys by Analysis of Data, Descriptive Survey, Correlational Studies, Causal Comparative, Instruments, Criteria for the Selection of Instruments

Unit 4. Experimental Research

Basic Characteristics of Experimental Design, General Components of experimental Research, Independent and Dependent Variables, Experimental and Control Group, Threats to an Experimental Study, Experimental Designs

Unit 5. Data Analysis

Evaluation of measurement, Analysis tools and various software, Errors and Precision, Statistical Methods, Mean Value and Variance, Errors of Direct measurements, Rejection of data, Significance of results, Propagation of errors, Errors of Computation. Data manipulation, smoothing, interpolation and extrapolation.

Unit 6. Report Writing

Interpretation and Report Writing: Technique of Interpretation, Precaution in Interpretation. Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report, Precautions for Writing Research Reports

Recommended books/reference material

6. Zięba A. (2023). *Analysis of experimental data in science and technology*. Cambridge Scholars Publishing.
7. Merriam S. B. & Tisdell E. J. (2020). *Qualitative research: A guide to design and implementation*. 5th edition. John Wiley & Sons.
8. Alasuutari P., & Qadir A. (2023). *Introduction to Research Methods: A Beginner's Guide To Quantitative, Qualitative, And Mixed Methods Research*. Routledge. London.
9. Creswell J. W., & Guetterman T. C. (2018). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, 6th Edition. Pearson. Publications.

Computational Physics

BS-Physics

Course Code: PHY-327

Credit Hours: 02

Prerequisites: Nil

Objectives

To make students understand how to program with any of the MATLAB, Mathematica and Python in solving physical problems with numerical methods.

Learning Outcomes

- Students will be able to implement numerical methods to solve physical problems and independently program computers using leading edge tools.
- Students will learn to develop and use computational algorithms for simulating physical systems.

Course Outline

Unit 1. Programming Introduction and Implementation of Mathematical Methods of Physics

Introduction to MATLAB, solution of linear algebraic equations, matrix algebra, matrix inverse, Arrays, User-defined functions, sorting and curve fitting and best fit using linear and nonlinear least square fits, Laplace transformation, Inverse Laplace transformation, Fourier transformation

Unit 2. Numerical Integration, Differentiation and Error Analysis Techniques

Solution of integral equations, Trapezoidal rule for numerical quadrature, Simpson method, Bisection method, Regular False method, Euler method, Secant method, Newton-Raphson method, Runge Kutta method.

Unit 3. Problems solving methods of Mechanics, Waves and Oscillations

Programming of projectile motion, simple pendulum, motion of falling objects, Simple Harmonic oscillator, Damped oscillator, Forced oscillator.

Unit 4. Electronics circuits, Heat and Thermodynamics Problems

Programming of RL series circuit, RC series circuit, Half wave rectifier, Full wave rectifier, Low pass RC filter, Ideal gas equation, Brownian motion.

Unit 5. Numerical methods of Quantum Mechanics

Numerical solutions to Schrodinger's equations, normalization of wave function, orthogonality of eigen functions.

Recommended Books/Reference Material

1. Boudreau J. F. Swanson E. S. & Bianchi R. M. (2021). *Applied computational physics*. Oxford University Press.
2. Garcia, A. L. (2020). *Numerical methods for physics*. CreateSpace.
3. Green, D. (2015). *More physics with MATLAB*. World Scientific.
4. Newman M. E. J. (2020). *Computational physics* (Revised and expanded). Createspace.
5. Pang, T. (2010). *Introduction to computational physics*. Cambridge.
6. Walker D. (2022). *Computational physics*. Mercury Learning & Information.

Computational Physics (Lab)

BS-Physics

Course Code: PHY-327L

Credit Hours: 01

Prerequisites: Nil

Objectives

To make students understand how to program with any of the MATLAB, Mathematica and Python in solving physical problems with numerical methods.

Learning Outcomes

- Students will be able to implement numerical methods to solve physical problems and independently program computers using leading edge tools.
- Students will learn to develop and use computational algorithms for simulating physical systems

List of Labs

1. Solve basic linear algebraic equations.
2. Solve matrix algebra, matrix inverse using 2x2 matrices, 3x3 matrices
3. Use different questions to solve arrays: one dimensional array, multi-dimensional array.
4. Solve different algebraic questions using user-defined functions
5. Plot different graphs of sorting and curve fitting and best fit using linear and nonlinear least square fits.
6. Implement Laplace transformation and Inverse Laplace transformation.
7. Use Fourier transformation to solve different mathematical equations.
8. Solve different equations using Trapezoidal rule for numerical quadrature, Simpson method, Bisection method, Regular False method, Euler method, Secant method, Newton-Raphson method and Runge-Kutta method.
9. Program different examples of projectile motion, simple pendulum, motion of falling objects, Simple Harmonic oscillator, Damped oscillator, Forced oscillator.
10. Programming of RL series circuit, RC series circuit, Half wave rectifier, Full wave rectifier, Low pass RC filter, Ideal gas equation, Brownian motion

Recommended books/reference material

1. Boudreau J. F. Swanson E. S. & Bianchi R. M. (2021). *Applied computational physics*. Oxford University Press.
2. Garcia, A. L. (2020). *Numerical methods for physics*. CreateSpace.
3. Green, D. (2015). *More physics with MATLAB*. World Scientific.
4. Newman M. E. J. (2020). *Computational physics* (Revised and expanded), Createspace.
5. Pang, T. (2010). *Introduction to computational physics*. Cambridge.
6. Walker D. (2022). *Computational physics*. Mercury Learning & Information.
- 7.

Medical Physics

BS-Physics

Course Code: PHY-410

Credit Hours: 03

Prerequisites: Nil

Objectives

Students will acquire understanding about different radiation, their interaction with matter, Radiotherapeutics techniques, different medical imaging techniques and their role in medical Physics.

Learning Outcomes

- Understanding different radiation and their interaction with matter
- Using principles of physics for measuring, examining and treating patients
- Learning of the application of physics for health.

Course Outline

Unit 1. Radiation

Introduction, Alpha-rays, Beta-rays, Gamma-rays, X-rays, Range-energy relationship, Energy transfer, Neutrons, production, characteristics of all types of radiation and their applications

Unit 2. Interactions of Radiation with Matter

Interaction mechanisms, range-energy relationships, mechanism of energy loss, ionization and excitation, exponential absorption, Pair production, Compton scattering, photoelectric absorption, photodisintegration, Combined effect, interaction, Scattering, Absorption.

Unit 3. Radiotherapy

Radiotherapy, development of radiotherapy, Radiotherapeutics aims, External beam therapy, Brachytherapy, Unsealed source therapy, Requirements for accuracy and precision, Quality assurance.

Unit 4. Medical Imaging

Medical Imaging, Diagnostic, Absorption of x-ray to other planes, Partial volume effect, Artifacts, Contrast agents in conventional radiography and CT, Diagnostic Ultrasound, Doppler effect, Radionuclide imaging, positron emission tomography (PET), Magnetic resonance imaging (MRI), Contrast agents for MRI.

Unit 5. Radiation Dosimetry

History of Absorbed Dose, Stochastic and Non-stochastic quantities, Absorbed Dose Calorimeters, Exposure and its measurements, The free-air chamber, Exposure measurement with calibrated cavity chamber, absorbed Dose in air, Absorbed dose in other Materials, Factors converting Exposure to Absorbed Dose to water, High energy calibrations, The Bragg Gray Cavity theory, Methods of Dosimetry, Calorimeters, Ionization chambers, Scintillation Detectors, Cardinal principles of radiation protection, Maximum permissible dose, whole-body occupational exposure, whole-body non-occupational exposure, partial body occupational exposure.

Recommended Books/Reference Material

1. Cember H. (1996). *Introduction to Health Physics*. 3rd Ed. McGraw Hill. New York.
2. Williams J. R. and D. I. Thwaites (1993). *Radiotherapy Physics*. Oxford University Press. New York
3. Bushong S. C. (1993). *Radiologic Science of Technologists*. 5th Ed. Mosby.
4. Greening J. R. (1985). *Fundamentals of Radiation Dosimetry*. 2nd Ed. Adam Hilger Ltd., Bristol

Artificial Intelligence in Physics

BS-Physics

Course Code: PHY-430

Credit Hours: 02

Prerequisites: Nil

Objectives

Students will acquire an understanding of principles and algorithms of Artificial Intelligence.

Learning Outcomes

- Understand the fundamental principles and algorithms of Artificial Intelligence relevant to solving physics problems.
- Apply AI techniques to model and simulate complex physical systems and phenomena.
- Evaluate the effectiveness of AI tools in optimizing and enhancing experimental and theoretical research in physics.

Course Outline

Unit 1. Introduction to Artificial Intelligence and Its Relevance to Physics

Definition and scope of AI, differences between AI, machine learning, and deep learning, historical evolution of AI in scientific discovery, overview of AI applications in theoretical physics, data analysis, and experimental automation.

Unit 2. Machine Learning for Physics

Supervised Learning: Regression and classification problems in physics, Applications in experimental data fitting (e.g., curve fitting, thermodynamic properties), Unsupervised Learning: Clustering techniques in physics data analysis and electronic signal classification,

Unit 3. Neural Networks and Deep Learning

Fundamentals of neural networks, Application in solving differential equations in physics, Convolutional and Recurrent Neural Networks: Time-series analysis for dynamical systems, Machine learning for noise reduction and filtering.

Unit 4. AI in Modeling and Simulation of Physical Systems

AI-assisted numerical modeling of differential equations, surrogate modeling and data-driven approaches for complex simulations, reinforcement learning in control systems and particle dynamics, optimization in quantum systems and thermodynamic processes using AI algorithms

Unit 5. AI for Experimental Physics and Data Analysis

Use of AI in automated experiments, noise reduction and filtering, real-time decision making in data collection, data fusion and anomaly detection, examples from particle physics, astrophysics, and condensed matter experiments, ethical considerations and limitations of AI in physics research

Recommended books/reference material

1. Mehta, P., Bukov, M., Wang, C.-H., Day, A. G. R., Richardson, C., Fisher, C. K., & Schwab, D. J. (2019). *A high-bias, low-variance introduction to Machine Learning for physicists*. Physics Reports
2. Ibe, O. C. (2022). *Machine Learning in Physics: Theoretical Foundations and Practical Applications*. CRC Press

3. Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly
4. Bar-Shalom, Y., & Fortmann, T. (1988). *Tracking and Data Association*. Academic Press
5. Carleo, G., Cirac, I., Cranmer, K., et al. (2019). *Machine learning and the physical sciences*.
Reviews of Modern Physics

Artificial Intelligence in Physics (Lab)

BS-Physics

Course Code: PHY-430L

Credit Hours: 01

Prerequisites: Nil

Objectives

Students will acquire an understanding of principles and algorithms of Artificial Intelligence.

Learning Outcomes

- Perform the fundamental principles and algorithms of Artificial Intelligence relevant to solve physics problems using AI tools (Python Libraries e.g. Tensor Flow, Matplotlib, NumPy).
- Apply AI techniques to model and simulate complex physical systems and phenomena.
- Evaluate the effectiveness of AI tools in optimizing and enhancing experimental and theoretical research in physics.

List of Experiments

1. Data preprocessing and visualization of experimental physics data using Python (NumPy, Pandas, Matplotlib)
2. Linear regression and classification applied to physical measurements (e.g., pendulum motion, resistor values)
3. Clustering unlabeled physical data (e.g., material classification based on thermal/electrical properties)
4. Design and training a simple feed-forward neural network to solve a regression problem in mechanics or optics
5. Use of CNNs to classify phase images or diffraction patterns from condensed matter simulations (simulated data)
6. Prediction of the motion of a damped harmonic oscillator using time-series forecasting (e.g., LSTM or ARIMA)
7. Reinforcement learning for simple particle motion control in a potential field (OpenAI Gym or custom environment)
8. Modeling and fitting of quantum tunneling or wavefunction profiles using neural networks
9. Application of AI to denoise or enhance signals from noisy experimental datasets (FFT + AI filter)
10. Train and evaluate an AI model for a selected physics problem (e.g., material property prediction, optical pattern recognition, or simulation optimization)

Recommended books/reference material

1. Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly
2. Ibe, O. C. (2022). *Machine Learning in Physics: Theoretical Foundations and Practical Applications*. CRC Press
3. Raschka, S., & Mirjalili, V. (2019). *Python Machine Learning* (3rd ed.). Packt Publishing
4. Mehta, P., et al. (2019). *A high-bias, low-variance introduction to Machine Learning for physicists*. Physics Reports
5. Virtually any up-to-date online tutorials for Python, TensorFlow, and Scikit-learn (MIT OCW, Coursera, etc.)

Artificial Intelligence

BS-Computer Science

Course Code: CS-206

Credit Hours: 03

Pre-requisite: Nil

Objectives

Artificial Intelligence (AI) is a constantly and actively growing and changing field. In this course, students will learn the basics of modern AI as well as some of the representative applications of AI. This course introduces students to the basic knowledge representation, problem solving, and learning methods of artificial intelligence. Upon completion, students should be able to develop intelligent systems by assembling solutions to concrete computational problems; understand the role of knowledge representation, problem solving, and learning in intelligent-system engineering; and appreciate the role of problem solving, vision, and language in understanding human intelligence from a computational perspective

Learning Outcomes

- Know various AI search algorithms (tree search, uninformed, informed, and heuristic), understand different types of AI agents, and know how to build simple knowledge-based systems.
- Ability to apply knowledge representation, reasoning, and machine learning techniques to real-world problems.

Course Outline

Unit 1. Introduction

What is AI, Major AI areas, Intelligent Agents: Agents and environments, Rationality? PEAS (Performance measure, Environment, Actuators, Sensors), Environment types, Agent Types, Problem solving through uninformed search: Breadth First Search, Depth First Search, Iterative DFS, Comparison of Search Algorithms.

Unit 2. Problem Solving Through Informed Search, Expert Systems

Problem solving through informed search: Heuristically Informed Methods, Hill Climbing, Beam Search, Best First Search, A*Procedure, Adversarial Search, Min-Max Procedure, Static Evaluation Function, Alpha Beta Pruning, Expert Systems: Knowledge Base Expert System Their Types and Application, Working of Expert Systems with its different components.

Unit 3. Neural Networks, Back Prop Algorithms

Binary Expert Systems: Developing an Expert System, Identifying the problem, forward and Backward Chaining. Neural Network: Introduction to Artificial Neural Networks (ANN), ANN Applications, Topologies of ANN, Single Layer perception (SLP).

Unit 4. Genetic Algorithm, Fuzzy System, Classification

Genetic Algorithm: Introduction to Evolutionary Computing, Genetic Algorithm (GA), Genetic operators (Crossover and Mutation) and its applications. Fuzzy System: Fuzzy Set Theory, Fuzzy Inference, And Classification: Decision Tree, Bayes Classification

Unit 5. Machine Learning, Introduction to Computer Vision, Mining Frequent Patterns

Machine Learning: Introduction to Learning, Supervised Machine Learning: Unsupervised Learning, K-means Clustering Algorithm, and Introduction to Computer Vision (CV), Pattern Recognition, Mining Frequent Patterns, Association and Correlation.

Recommended Books/Reference Material

1. Finlay, J. (2020). *An introduction to artificial intelligence*. Crc Press.
2. Joshi, P. (2017). *Artificial intelligence with python*. Packt Publishing Ltd.
3. Le, D., Chung, K., Quach, S., & Thaichon, P. (2022). *Introduction to artificial intelligence (AI). Artificial Intelligence for Marketing Management*.
4. Luger, G. F. (2005). *Artificial intelligence: structures and strategies for complex problem solving*. Pearson education.
5. Mehrotra, D. (2019). *Basics of artificial intelligence & machine learning*. Notion Press.
6. Miller, B. N., Ranum, D. L., & Anderson, J. (2019). *Python programming in context*. Jones & Bartlett Learning.

Artificial Intelligence (Lab)

BS-Computer Science

Course Code: CS-206L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Study the applications of AI and agent-based approach to AI and First-order predicate calculus, logical reasoning and problem-solving using Prolog language. To study and discuss various techniques and algorithms of AI used in general problem solving, optimization problems, constraint satisfaction problems, and game programming. Familiarize students with various sub-areas of AI, such as expert systems, natural language processing and machine learning.

Learning Outcomes

- Explain artificial intelligence, its characteristics and its application areas
- Formulate real-world problems as state space problems, optimization problems or constraint satisfaction problems.
- Select and apply appropriate algorithms and AI techniques to solve complex problems.
- Design and develop an expert system by using appropriate tools and techniques.

Course Outline

- Unit 1. Problem Solving**
Problem solving (2 jug puzzles, 3 jug puzzles, lion man puzzles, vacuum cleaner puzzle. Implementation of 2 jug puzzles, 3 jug puzzles, lion man puzzles, vacuum cleaner puzzle using DFS and BFS.
- Unit 2. Cost Search Algorithm Implementation**
Implementation of A* and Uniform cost search algorithms to solve problems. Implementation of different games using game search tree algorithms
- Unit 3. Game Search Algorithm Implementation**
Implementation of different games using game search tree algorithm Solution of 8 queen problem using genetic algorithm.
- Unit 4. 8 Queen Problem And Prolog Language**
Solution of 8 queen problem using genetic algorithm. Learning Prolog language for Logic Practice of Prolog and Lisp.
- Unit 5. K Means Clustering Algorithm and Neural Networks**
Implementation of K mean clustering algorithm. Implementation of single layer neural network.

Recommended Books/Reference Material

1. Finlay, J. (2020). *An introduction to artificial intelligence*. Crc Press.
2. Joshi, P. (2017). *Artificial intelligence with python*. Packt Publishing Ltd.
3. Le, D., Chung, K., Quach, S., & Thaichon, P. (2022). *Introduction to artificial intelligence (AI). Artificial Intelligence for Marketing Management*.
4. Luger, G. F. (2005). *Artificial intelligence: structures and strategies for complex problem solving*. Pearson education.
5. Mehrotra, D. (2019). *Basics of artificial intelligence & machine learning*. Notion Press.
6. Miller, B. N., Ranum, D. L., & Anderson, J. (2019). *Python programming in context*. Jones & Bartlett Learning.

Introduction to Data Science

BS-Computer Science

Course Code: CS-414

Credit Hours: 02

Pre-requisite: Artificial Intelligence

Objectives

The objective of Data Science is to generalize knowledge from data and integrate integrated skill set spanning mathematics, statistics, machine learning, databases and other branches of computer science along with a good understanding of the craft of problem formulation to engineer effective solutions. Similarly introduce students to this rapidly growing field and equip them with some of its basic principles and tools as well as its general mindset. Explain the significance of exploratory data analysis in data science. Identify common approaches used for Feature Generation as well as Feature Selection, and finally discuss the Ethical and Privacy issues. Programming language Python has been proposed for the practical work of this course.

Learning Outcomes

- Describe what Data Science is and the skill sets needed to be a data scientist.
- Apply EDA and the Data Science process in a case study.
- Comprehend the fundamental constructs of Python programming language.
- Apply basic machine learning algorithms to solve real world problems of moderate complexity.

Course Outline

Unit 1. Introduction to Data Science

What is Data Science? Big Data and Data Science hype, Datafication, Current landscape of perspectives, Skill sets needed.

Unit 2. Statistical Inference

Populations and samples, Statistical modeling, probability distributions, fitting a model.

Unit 3. Introduction to Python

Exploratory Data Analysis and the Data Science Process; Basic Machine Learning Algorithms: Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes; Feature Generation and Feature Selection.

Unit 4. Machine Learning Algorithms

Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis; Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs

Unit 5. Data Visualization

Data Visualization: Basic principles, ideas and tools for data visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists.

Recommended Books/Reference Material

1. Blum, A., Hopcroft, J., & Kannan, R. (2020). Foundations of data science. Cambridge University Press.
2. Efron, B., & Hastie, T. (2021). Computer age statistical inference, student edition: algorithms, evidence, and data science (Vol. 6). Cambridge University Press.
3. Grus, J. (2019). Data science from scratch: first principles with python. O'Reilly Media.

4. Peyré, G., & Cuturi, M. (2019). Computational optimal transport: With applications to data science. Foundations and Trends® in Machine Learning.
5. Saura, J. R. (2021). Using data sciences in digital marketing: Framework, methods, and performance metrics. Journal of Innovation & Knowledge.

Introduction to Data Science (Lab)

BS-Computer Science

Course Code: CS-414L

Credit Hours: 01

Pre-requisite: Artificial Intelligence

Objectives

The objective of Data Science is to generalize knowledge from data and integrate integrated skill set spanning mathematics, statistics, machine learning, databases and other branches of computer science along with a good understanding of the craft of problem formulation to engineer effective solutions. Similarly introduce students to this rapidly growing field and equip them with some of its basic principles and tools as well as its general mindset. Explain the significance of exploratory data analysis in data science. Identify common approaches used for Feature Generation as well as Feature Selection, and finally discuss the Ethical and Privacy issues. Programming language Python has been proposed for the practical work of this course.

Learning Outcomes

- Learn in-demand skills from market and industry experts.
- Master a subject or tool with hands-on projects.
- Develop a deep understanding of key concepts.

Course Outline

Unit 1. Introduction To Data Science

What is Data Science? Big Data and Data Science hype, Datafication, Current landscape of perspectives, Skill sets needed.

Unit 2. Statistical Inference

Tools for data science, Describe the Data Scientist's tool kit which includes: Libraries & Packages, Data sets, Machine learning models, and Big Data tools. Utilize languages commonly used by data scientists like Python, R, and SQL.

Unit 3. Introduction to Python

Demonstrate working knowledge of tools such as Jupyter notebooks and RStudio and utilize their various features. Create and manage source code for data science using Git repositories and GitHub.

Unit 4. Machine Learning Algorithms

Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis; Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs

Unit 5. Data Visualization

Data Visualization: Basic principles, ideas and tools for data visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists.

Recommended Books/Reference Material

1. Blum, A., Hopcroft, J., & Kannan, R. (2020). Foundations of data science. Cambridge University Press.
2. Efron, B., & Hastie, T. (2021). Computer age statistical inference, student edition: algorithms, evidence, and data science (Vol. 6). Cambridge University Press.
3. Grus, J. (2019). Data science from scratch: first principles with python. O'Reilly Media.

4. Peyré, G., & Cuturi, M. (2019). Computational optimal transport: With applications to data science. Foundations and Trends® in Machine Learning.
5. Saura, J. R. (2021). Using data sciences in digital marketing: Framework, methods, and performance metrics. Journal of Innovation & Knowledge.

17. List of Courses Offered by the Physics Department

Course Code	Course Title	Course Category	Prereq	Cr Hrs
PHY-103	Applied Physics	General Education (Natural Science)	Nil	2
PHY-103L	Applied Physics (Lab)	General Education (Natural Sciences)	Nil	1
PHY-104	Introduction to Mechanics	Allied / Interdisciplinary	Nil	3
PHY-104L	Introduction to Mechanics (Lab)	Allied / Interdisciplinary	Nil	1
PHY-105	General Physics	General Education (Natural Science)	Nil	2
PHY-105L	General Physics (Lab)	General Education (Natural Science)	Nil	1
PHY-106	Everyday Physics	General Education (Natural Science)	Nil	2
PHY-106L	Everyday Physics (Lab)	General Education (Natural Science)	Nil	1
PHY-107	Biophysics	Allied / Interdisciplinary	Nil	3
PHY-328	Introduction to Classical Mechanics	Allied / Interdisciplinary	Nil	3
PHY-329	Materials Science	Allied / Interdisciplinary	Nil	2
PHY-329L	Materials Science (Lab)	Allied / Interdisciplinary	Nil	1

18. Course Outlines of the Courses Offered by the Physics Department

Applied Physics

Physics Department

Course Code: PHY-103

Credit Hours: 02

Prerequisites: Nil

Objectives

The main objective of the course is to provide basic information about Mechanics, Electricity, Magnetism, Electromagnetism, Waves and oscillations, optics, and Electronics to the technology students. The course gives the students a sound knowledge of Physics with its applications to problems of practical nature

Learning Outcomes

- Apply fundamental principles of mechanics, relativity, and vector analysis to solve problems involving motion, force, and planetary dynamics.
- Analyze electric and magnetic fields in physical systems, including the behavior of capacitors, inductors, and DC circuits.
- Explain the working principles and applications of semiconductor devices such as diodes, transistors, and LEDs based on their electronic structure.

Course Outline

Unit 1. Physics Fundamentals

Basic concept of units, vectors and scalars, measurements and uncertainties, Addition of vectors by graphical and component method. Multiplication of vectors, vectors in three dimensions,

Unit 2. Newton's Laws and Relativity

Newton's laws of motion and their applications, Work and Kinetic Energy, Gravitation, Circular motion, projectile motion, orbits of planets, linear and angular momenta, basic concepts of general and special theory of relativity.

Unit 3. Electricity

Conductors and Insulators, Electrostatic Force, Capacitors and Dielectrics, Capacitance, Energy store in capacitor (Capacitor as memory device), DC Circuits, Measuring V, I, R, RC Circuits.

Unit 4. Magnetism

Magnetic Fields, Magnetic Force, Magnetic Field, Magnetic Field Energy, inductors and inductance, energy stored in inductor (inductor as memory device) magnetic materials.

Unit 5. Semiconductors

Semi-Conductors Energy levels in a semi-conductor, Hole concept, Intrinsic and Extrinsic regions, PNP, NPN junction Transistor, LEDs.

Recommended Books/Reference Material

1. Beiser A. & Hademenos G. J. (2012). *Applied physics*. McGraw Hill.
2. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
3. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics*, Extended (12th ed.). Wiley.
4. Hecht E. (2021). *College physics*. McGraw Hill Education.
5. Serway, R. A., & Jewett, J. W. (2018). *Physics for scientists and engineers* (10th ed.). Cengage Learning.

Applied Physics (Lab)

Physics Department

Course Code: PHY-103L

Credit Hours: 01

Prerequisites: Nil

Objectives

The course objectives are to enable students to comprehend and apply fundamental principles of measurement, elasticity, electrical circuits, and logic gates. They should develop the ability to conduct experiments, analyze data, and manipulate instruments for various measurement and electrical applications, fostering a solid foundation in experimental physics and electronics.

Learning Outcomes

- Demonstrate a solid understanding of fundamental principles in applied physics, including mechanics, thermodynamics, and electromagnetism.
- Apply mathematical and computational techniques to analyze and solve real-world problems in various branches of applied physics.
- Develop practical skills in laboratory experiments, data acquisition, and analysis, enhancing the ability to apply theoretical concepts to hands-on situations.
- Communicate effectively, both orally and in writing, about complex physics concepts, experimental results, and their applications in practical scenarios.

List of Experiments

1. Study and understand the working principle of Vernier caliper and Screw Gauge.
2. Study Hooke's Law using the mass-spring system, determining the stiffness (k -value) of the spring.
3. Investigate the relationship between the length of a pendulum and its period of oscillation.
4. Determine the internal resistance of a galvanometer using the half deflection method.
5. Experiment with various resistors and voltage sources to verify Ohm's law ($V = IR$) by measuring voltage, current, and resistance in a circuit.
6. Convert a galvanometer into a voltmeter.
7. Convert a galvanometer into an ammeter.
8. Study the series and parallel configurations of capacitors and resistors and verify binary truth tables using logic gates.

Recommended Books/Reference Material

1. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
2. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics*, Extended (12th ed.). Wiley.
3. Hecht E. (2021). *College physics*. McGraw Hill Education.
4. Loyd, D. H. (2008). *Physics laboratory manual*. Thomson Higher Education.
5. Smith, W. F. (2020). *Experimental physics: principles and practice for the laboratory*. Taylor and Francis.

6. Wilson, J. D., & Hernández-Hall, C. A. (2014). *Physics laboratory experiments*. Cengage Learning.

Introduction to Mechanics

Physics Department

Course Code: PHY-104

Credit Hours: 02

Prerequisites: Nil

Objectives

This course introduces the fundamental principles of mechanics, emphasizing motion, forces, energy, and wave behavior. It aims to develop students' ability to apply physical laws and use them to solve problems in physical systems.

Learning Outcomes

- Understand the basic concepts such as mechanics and electromagnetism
- Apply physical principles to solve problems in mechanics and waves
- Analyze experimental data to validate physical laws and theories

Course Outline

Unit 1. Kinematics

Displacement, velocity, acceleration, equations of motion for constant acceleration, vector analysis of motion, projectile motion, circular motion

Unit 2. Newton's Laws of Motion

Newton's laws and their applications, force and mass, free-body diagrams, tension, normal and frictional forces, dynamic equilibrium

Unit 3. Work, Energy, and Power

Work-energy theorem, mechanical energy, conservation of energy, potential and kinetic energy, power output and efficiency in mechanical systems

Unit 4. Momentum and Collisions

Linear momentum, impulse, conservation of momentum, elastic and inelastic collisions, applications in transportation and impact analysis

Unit 5. Mechanical Waves

Wave characteristics, simple harmonic motion, wave speed, frequency, resonance, interference, reflection and transmission of waves

Recommended Books/Reference Material

1. Serway, R. A., & Vuille, C. (2021). *College Physics* (11th ed.). Cengage
2. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics* (12th ed). Wiley
3. Giambattista, A., Richardson, B. M. C., & Richardson, R. C. (2020). *College Physics*. McGraw-Hill
4. Hewitt, P. G. (2016). *Conceptual Physics* (12th ed). Pearson

Introduction to Mechanics (Lab)

Physics Department

Course Code: PHY-104L

Credit Hours: 01

Prerequisites: Nil

Objectives

This course complements the theory of mechanics by providing practical exposure to fundamental experiments in kinematics, dynamics, energy, and wave motion. It is designed to develop students' skills in measurement, experimental design, and data interpretation.

Learning Outcomes

- Perform experiments in classical mechanics and analyze physical quantities related to motion and forces
- Use basic lab apparatus to verify physical laws in mechanics
- Interpret experimental data, plot relevant graphs, and draw meaningful conclusions

List of Experiments

1. Determination of gravitational acceleration using a simple pendulum
2. Verification of equations of motion using ticker timer or motion sensor
3. Analysis of uniformly accelerated motion on an inclined plane
4. Determination of force and acceleration relationship using Atwood's machine
5. Study of conservation of mechanical energy using a pendulum or spring system
6. Verification of conservation of momentum using elastic and inelastic collisions
7. Determination of spring constant and validation of Hooke's law
8. Measurement of mechanical power output in a stair-climbing activity
9. Observation of wave behavior on a stretched string and verification of wave speed relation
10. Study of resonance in mechanical systems using a vibrating system

Recommended Books/Reference Material

1. Arora, C. L. (2001). *B.Sc. Practical Physics*. S. Chand & Company
2. Squires, G. L. (2017). *Practical Physics* (4th ed). Cambridge University Press
3. Serway, R. A., & Vuille, C. (2021). *College Physics – Laboratory Manual* (11th ed). Cengage
4. Taylor, J. R. (1997). *An Introduction to Error Analysis* (2nd ed). University Science Books

General Physics

BS-Physics

Course Code: PHY-105

Credit Hours: 02

Prerequisites: Nil

Objectives

This course introduces fundamental physics concepts with an emphasis on their practical relevance to the physical sciences. It aims to develop students' conceptual understanding and problem-solving abilities in areas such as motion, forces, energy, matter, and heat, providing a foundation for interdisciplinary applications.

Learning Outcomes

- Understand and apply core concepts of mechanics, electromagnetism, and waves.
- Translate physical phenomena into mathematical models.
- Solve basic physics problems using analytical methods.

Course Outline

Unit 1. Mechanics and Kinematics

Motion in one and two dimensions, displacement, velocity, acceleration; Newton's laws of motion; applications to particle motion; conservation of momentum and energy; circular motion.

Unit 2. Oscillations and Waves

Simple harmonic motion, energy in oscillations; wave motion in one dimension; speed, frequency, and wavelength; interference and superposition; standing waves.

Unit 3. Fluid Mechanics and Thermodynamics

Pressure, buoyancy, continuity equation, Bernoulli's principle; temperature and heat, ideal gas law, first law of thermodynamics, heat capacity and thermal processes.

Unit 4. Electricity and Magnetism

Electric charge and field, Gauss's law, electric potential; current, resistance, Ohm's law, Kirchhoff's laws; magnetic fields, Ampere's law, electromagnetic induction (Faraday's law).

Unit 5. Light and Optics

Nature of light; reflection, refraction, Snell's law; lenses and mirrors; interference and diffraction (qualitative).

Recommended Books/Reference Material

1. Giambattista, A., Richardson, B. M. C., & Richardson, R. C. (2020). *College Physics*. McGraw-Hill.
2. Hewitt, P. G. (2016). *Conceptual Physics* (12th ed.). Pearson.
3. Serway, R. A., & Vuille, C. (2021). *College Physics* (11th ed.). Cengage.
4. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics* (12th ed.). Wiley.

General Physics (Lab)

Physics Department

Course Code: PHY-105L

Credit Hours: 01

Prerequisites: Nil

Objectives

This laboratory course complements the theoretical content of general physics, offering hands-on experience in fundamental physical principles. The emphasis is on basic measurement techniques, error analysis, and strengthening the understanding of classical mechanics, electromagnetism, and waves through experimentation.

Learning Outcomes

- Demonstrate understanding of basic physical principles through hands-on experiments.
- Apply measurement techniques and perform uncertainty/error analysis.
- Use laboratory equipment effectively to observe and quantify physical phenomena.

List of Experiments

1. Measurement and Error Analysis
2. Verification of Newton's Second Law
3. Conservation of Momentum on an Air Track
4. Simple Harmonic Motion Using a Mass-Spring System
5. Wave Speed on a String
6. Verification of Ohm's Law
7. Kirchhoff's Rules for DC Circuits
8. Magnetic Field of a Current-Carrying Coil
9. Refraction Through a Glass Slab
10. Young's Double-Slit Experiment (Simulation)

Recommended Books/Materials

1. Serway, R. A., & Vuille, C. (2021). *College Physics – Laboratory Manual* (11th ed.). Cengage.
2. van Heuvelen, A. (2005). *Active Learning in Introductory Physics*. Cengage.

Everyday Physics

Physics Department

Course Code: PHY-106

Credit Hours: 02

Prerequisites: Nil

Objectives

This course introduces the exciting world of physics not through dry formulas, but through real-world stories, hands-on applications, and surprising phenomena that shape our daily lives. Whether it's how your phone knows if you've turned it sideways, or how an athlete's motion is a masterpiece of mechanics, students will build an intuitive and enjoyable understanding of physics concepts while developing problem-solving skills relevant to science and life.

Learning Outcomes

- Understand how motion, force, and energy explain everyday experiences.
- Apply physics principles to situations like car crashes, amusement park rides, sports, and cooking.
- Connect heat and energy concepts to home appliances, climate, and biological systems.

Course Outline

Unit 1. How Things Move

Stories of speeding cars, jumping frogs, and roller coasters. Displacement, velocity, acceleration — visualizing them through real motion. Projectiles and what they have in common with basketball, archery, and Angry Birds.

Unit 2. Why Things Move (or Don't)

From sumo wrestling to pulling a stubborn drawer: Newton's Laws in action. Friction: hero in walking, villain in machinery. What keeps the Earth in orbit or a car on a turn?

Unit 3. Powering the Planet

Energy at work from coffee to crashing waves. Understanding power, energy, and "efficiency" using mobile phones, fuel, and muscles. Roller coasters and pendulums: where energy hides and reappears.

Unit 4. The Physics of Collisions

Why airbags save lives: the magic of momentum. Sports collisions, dancing billiard balls, and how physics improves helmet design. Explosions, rockets, and conservation of momentum in zero gravity.

Unit 5. Heat, Temperature & Everyday Thermodynamics

Why metal feels colder than wood, how microwaves cook food, and why refrigerators don't break the laws of nature. Heat flow in kitchens, greenhouses, and thermos flasks. The First Law of Thermodynamics explained through engines, metabolism, and survival in the cold.

Recommended Books/Reference Material:

1. Hewitt, P. G. (2016). *Conceptual Physics* (12th ed.). Pearson.
2. Giambattista, A., Richardson, B. M. C., & Richardson, R. C. (2020). *College Physics*. McGraw-Hill.
3. Bloomfield, L. A. (2013). *How Things Work: The Physics of Everyday Life* (6th ed.). Wiley.
4. Serway, R. A., & Vuille, C. (2021). *College Physics* (11th ed.). Cengage.

Everyday Physics (Lab)

BS-Physics

Course Code: PHY-106L

Credit Hours: 01

Prerequisites: Nil

Objectives

This course turns physics into a personal experience, not just something to memorize, but something to touch, test, and explore. Students will use basic equipment (and sometimes creative props) to discover how physics really works and realize that science is not about answers, but about exploration.

Learning Outcomes

- Use experiments to understand how physical laws work in the real world.
- Relate hands-on findings to the theory discussed in class.
- Communicate their observations through creative, clear lab reports.

List of Experiments:

1. Measure gravity using a pendulum and compare it with gravity on other planets.
2. Use timers or sensors to calculate your walking speed.
3. Slide objects down different ramp surfaces and compare friction.
4. Launch carts or projectiles with springs to study energy conversion.
5. Observe collisions using carts and analyze momentum conservation.
6. Compare how fast different materials heat up in water.
7. Determine specific heat using a simple calorimeter setup.
8. Observe thermal expansion of solids like rods or rubber bands.
9. Test insulation performance using DIY thermos containers.
10. Use spring balances to explore action-reaction forces.
11. Drop balls and compare bounce heights to study energy loss.
12. Roll objects down ramps to examine energy and acceleration.
13. Balance uneven objects to find their center of mass.
14. Drop balls on soft and hard surfaces to explore impulse effects.
15. Use balloons and hot water to visualize gas expansion.
16. Time stair climbing and calculate human mechanical power output.

Recommended Books/Materials

1. Arora, C. L. (2001). *B.Sc. Practical Physics*. S. Chand & Company.
2. Serway, R. A., & Vuille, C. (2021). *College Physics – Laboratory Manual* (11th ed.). Cengage.
3. van Heuvelen, A. (2005). *Active Learning in Introductory Physics*. Cengage.

Biophysics

Physics Department

Course Code: PHY-107

Course Type: Interdisciplinary

Credit Hours: 3

Objectives

Students will have the theoretical foundation to understand the properties of macromolecular functions and understand the principles by which their actions are simulated. Students will be able to critically assess primary literature written for a general scientific audience in the area of macromolecular structure & function, understanding the experimental basis in crystallography, NMR and spectroscopy.

Learning Outcomes

- Understand the fundamental concepts of biophysics and its scope.
- Comprehend spatial and temporal scales relevant to biophysics.
- Utilize statistical mechanics to understand equilibria, reactions, binding, and conformation.
- Explain the principles of transport and diffusion in biological membranes.
- Explain the use of magnetic resonance imaging (MRI) in studying biomolecular structures.

Course Outline

Unit 1. Introduction to Biophysics

Overview of Biophysics: History and Scope. Basic Concepts in Physics Relevant to Biology: Energy, Force, and Motion.

Unit 2. Structure and Dynamics of Biomolecules

Introduction to Biological Macromolecules: Proteins, Nucleic Acids, Lipids, and Carbohydrates. Molecular Forces and Interactions: Covalent Bonds, Hydrogen Bonds, Van der Waals Forces, Hydrophobic Interactions.

Unit 3. Techniques in Biophysics

Spectroscopic Techniques: UV-Vis, Fluorescence, NMR, and EPR. Microscopy Techniques: Light, Electron, and Atomic Force Microscopy. X-ray Crystallography, Force Spectroscopy.

Unit 4. Membrane Biophysics

Structure and Function of Biological Membranes. Membrane Potential and Ion Channels. Transport Mechanisms: Diffusion, Osmosis, Active Transport.

Unit 5. Molecular Motors and Dynamics

Physics of Molecular Motors: Kinesin, Dynein, and Myosin. ATP Hydrolysis and Energy Transduction. Brownian Motion and Diffusion. Biophysical Properties.

Unit 6. Applications of Biophysics

Biophysics in Medicine: Imaging Techniques, Radiation Therapy. Drug Design and Molecular Dynamics Simulations. Nanotechnology and Biosensors. Current Trends and Research in Biophysics.

Recommended books/ Reference material

1. Allewell, N. M., Narhi, L. O., & Rayment, I. (2020). *Molecular biophysics for the life sciences*

- (1st ed.). Springer-Verlag New York.
2. Boal, D. (2012). *Mechanics of the Cell*. Cambridge University Press.
 3. Cotterill, R. (2002). *Biophysics: An introduction* (1st ed.). John Wiley & Sons.
 4. Denizli, A. (2023). *Biophysics at the nanoscale: Applications of functional materials* (1st ed.). Elsevier.
 5. Howard, J. (2024). *Mechanics of Motor Proteins and the Cytoskeleton*. Sinauer Associates.
 6. Nelson, P. (2021). *Biological Physics: Energy, Information, Life*. W.H. Freeman.
 7. Phillips, R., Kondev, J., Theriot, J., & Garcia, H. G. (2012). *Physical Biology of the Cell*. Garland Science.
 8. Stanford, A. L. (2013). *Foundations of biophysics*. Elsevier Science.
 9. Van Holde, K. E., Johnson, C., & Ho, P. S. (2006). *Principles of physical biochemistry* (2nd ed.). Prentice Hall.
 10. Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2018). *Principles of Physical Biochemistry*. Pearson.

Introduction to Classical Mechanics

Physics Department

Course Code: PHY-328

Course Type: Interdisciplinary

Credit Hours: 3

Objectives

This course provides a rigorous foundation in classical mechanics, from Newton's laws to the analytical formulations of Lagrange and Hamilton. It prepares students to model and analyze the dynamics of particles and rigid bodies and introduces principles of conservation laws.

Learning Outcomes

- Understand Newton's laws of motion and their applications to mechanical systems.
- Apply Lagrangian and Hamiltonian mechanics to solve advanced dynamics problems.
- Analyze the conservation of energy and momentum in physical systems.

Course Outlines

Unit 1. Kinematics

Rectilinear motion, uniform and uniformly accelerated rectilinear motion. Tangential and normal components, radial and transverse components, projectile motion.

Unit 2. Kinetics

Work, power, kinetic and potential energy. Conservative force field, conservation of energy. Impulse, torque, conservation of linear and angular momentum, non-conservative force. Rotating axes, Rate of change of vector; Application to motion relative to rotating earth, Newton's laws of motion; Work, energy and power; conservative forces (N.A.S.C for a force to be conservative), potential energy.

Unit 3. Simple Harmonic Motion and Central Forces

The simple harmonic motion. The damped harmonic oscillator. Central forces fields. Equations of motion.

Unit 4. Planetary Motion of Rigid Bodies

Kepler's law of planetary motion. Motion in an inverse square field. Introduction to rigid and elastic bodies, degree of freedom, Euler's and Chasles's theorem, Rotation of a rigid body about a fixed axis. Moments and products of inertia, parallel and perpendicular axis theorem.

Unit 5. Motion of Rigid Bodies in Three Dimensions

General motion of rigid bodies in space. Momental ellipsoid and equi-momental systems. Angular momentum vector and rotational kinetic energy. Principal axis and principal moments of inertia. Force free motion, free rotation of a rigid body with an axis of symmetry and with three different principal moments. Euler's angles, motion of a spinning top, sleeping top, Systems of Particles. Generalized coordinates, D'Alembert's principle, Lagrange's equation of motion, Applications to theory of small oscillation. Techniques of Lagrangian and Hamiltonian mechanics for solving the dynamic problems

Recommended Books

1. Deshmukh, P. C. (2019). *Foundations of Classical Mechanics*. India: Cambridge University Press
2. Goldstein, H. (2011). *Classical Mechanics*. India: Pearson.
3. Helliwell, T. M., Sahakian, V. V. (2021). *Modern Classical Mechanics*. United Kingdom: Cambridge University Press.
4. Kamberaj, H. (2021). *Classical Mechanics*. Germany: De Gruyter.

6. Philpot, T. A., Thomas, J. S. (2020). *Mechanics of Materials: An Integrated Learning System*. United Kingdom: Wiley.

Materials Science

Physics Department

Course Code: PHY-329

Credit Hours: 02

Prerequisites: Nil

Objectives

This course is designed to introduce students to the physical structure and behavior of materials. It focuses on the relationship between chemical bonding, microstructure, and the macroscopic properties of materials including metals, ceramics, and polymers. Students will also explore key techniques for material characterization and evaluate material selection strategies in industrial and technological applications.

Learning Outcomes

- Explain the relationship between chemical structure, properties, and applications of different materials, including metals, ceramics, and polymers
- Characterize materials using techniques such as X-ray diffraction and electron microscopy
- Evaluate the selection and design of materials for specific industrial and technological applications

Course Outline

Unit 1. Structure of Materials

Atomic bonding in solids, crystal structures of metals and ceramics, amorphous and semi-crystalline structures in polymers, unit cells and lattice types, coordination number, atomic packing factor

Unit 2. Imperfections and Diffusion

Point, line, and planar defects, dislocations and their motion, diffusion mechanisms in solids, Fick's laws of diffusion, temperature dependence of diffusion, relevance to chemical synthesis and material processing

Unit 3. Mechanical Properties

Stress-strain relationships, elastic and plastic deformation, tensile and hardness testing, fracture, fatigue, creep, strengthening mechanisms in metals and polymers

Unit 4. Thermal, Electrical and Optical Properties

Thermal expansion, heat capacity, thermal conductivity, electrical conductivity of metals and semiconductors, dielectric behavior of ceramics and polymers, introduction to optical properties such as transparency and color in solids

Unit 5. Characterization and Material Selection

X-ray diffraction (XRD) basics and applications, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), thermal analysis techniques (TGA/DSC), criteria for selecting materials for chemical reactors, biomedical devices, and consumer products.

Recommended Books/Reference Material

1. Callister, W. D., & Rethwisch, D. G. (2021). *Materials Science and Engineering: An Introduction* (10th ed). Wiley
2. Shackelford, J. F. (2020). *Introduction to Materials Science for Engineers* (9th ed). Pearson
3. Smith, W. F., & Hashemi, J. (2022). *Foundations of Materials Science and Engineering* (6th ed). McGraw-Hill
4. Cullity, B. D., & Stock, S. R. (2020). *Elements of X-Ray Diffraction* (3rd ed). Pearson
5. Van Vlack, L. H. (2001). *Elements of Materials Science and Engineering* (6th ed). Addison-Wesley

Materials Science (Lab)

Physics Department

Course Code: PHY-329L

Credit Hours: 01

Prerequisites: Nil

Objectives

This lab course introduces students to the experimental methods used in the physical characterization of materials. It focuses on basic mechanical, thermal, and structural analysis techniques that are essential for understanding the behavior and selection of materials in chemistry-related applications.

Learning Outcomes

- Perform basic tests to evaluate physical properties of materials
- Use laboratory tools to characterize structural features of metals, ceramics, and polymers
- Interpret experimental results and relate them to material structure and function

List of Experiments

1. Identification of crystal structures using model kits and unit cell geometry
2. Tensile strength measurement of polymer or metal samples
3. Microstructure observation of metal or ceramic samples using optical microscopy
4. Measurement of hardness using Vickers or Brinell method
5. Grain size estimation using metallographic techniques
6. Thermal expansion analysis using dilatometer or comparative method
7. Introduction to X-ray diffraction: pattern recognition and lattice spacing calculation
8. Surface morphology analysis using sample SEM images (demo or virtual lab)
9. Electrical conductivity measurement of metal wires and semiconductors
10. Differential scanning calorimetry (DSC) or thermogravimetric analysis (TGA) of a polymer sample

Recommended Books/Reference Material

1. Suryanarayana, A. K. (1995). *Experimental Techniques in Materials and Mechanics*. CRC Press
2. Cullity, B. D., & Stock, S. R. (2014). *Elements of X-Ray Diffraction* (3rd ed). Pearson
3. Arora, C. L. (2001). *B.Sc. Practical Physics*. S. Chand & Company
4. Taylor, J. R. (1997). *An Introduction to Error Analysis* (2nd ed). University Science Books
5. Shackelford, J. F. (2020). *Introduction to Materials Science for Engineers* (9th ed). Pearson