GOVERNMENT COLLEGE(A):: RAJAHMUNDRY
DEPARTMENT OF PHYSICS
I.B.Sc.-MATERIAL SCIENCE
SEMESTER-I
COURSE-1: MATHEMATICAL FOUNDATION FOR MATERIAL SCIENCE
w.e.f 2025-26

Hours: 45 Credits: 3

COURSE OBJECTIVE:

To equip students with foundational mathematical techniques—such as vector calculus, linear algebra, complex numbers, probability, and Fourier analysis—essential for understanding and solving problems in physics.

LEARNING OUTCOMES:

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

- Apply concepts of vector differentiation and integration to analyze physical fields and prove integral theorems.
- Use matrix operations and eigenvalue techniques to solve linear systems in physics.
- Represent and manipulate complex numbers in various forms for solving AC circuit problems.
- Interpret and apply basic probability concepts and distributions to model physical phenomena.
- Analyze periodic signals using Fourier series and evaluate Fourier coefficients for common waveforms.

UNIT-I - VECTOR ANALYSIS (9. Hrs.)

Distinction between Ordinary and partial derivatives, Scalar and vector fields, gradient of a scalar field and its physical significance. Divergence and curl of a vector field with derivations and physical interpretation. Vector integration (line, surface and volume), Statement and proof of Gauss and Stokes theorems.

UNIT-II – LINEAR ALGEBRA (9. Hrs.)

Vector and Scalar quantities in Physics, Matrices and Operations: Types, Addition and Multiplication, Identity and Inverse, Determinant (2x2 and 3x3), Trace, Transpose, Eigenvalues and Eigen Vectors, Calculation of Eigen values using characteristic equations. System of Linear Equations: Solving 2-variable system using matrices, Simple examples from physics (Current, forces)

UNIT – III COMPLEX NUMBERS (9. Hrs.)

Basic Complex numbers: Real and imaginary parts, Conjugate of complex numbers, Modulus and argument (magnitude and phase), Polar and Exponential (Euler) form of complex numbers. Addition and subtraction of complex numbers, Multiplication and division of complex numbers. Phasor representation: representation of voltage and current as phasors, Derivation of Impedance of a series LCR circuit.

UNIT – IV PROBABILITY (9. Hrs.)

Probability Theory Basics, Sample space, events, conditional probability, and Bayes' theorem. Independence and mutual exclusivity. Random Variables and Probability Distributions, Concept of random variables (discrete and continuous). Common distributions and their applications: Binomial, Poisson, and Gaussian.

UNIT V FOURIER ANALYSIS (9. Hrs.)

Introduction to periodic functions: Concept of periodicity (waves, oscillations, AC current), Graphical understanding of Sine and Cosine functions, Need for Fourier analysis, Real world signals (heartbeat, electrical signal, musical tones), Fourier theorem ad evaluation of Fourier coefficients, Analysis of periodic wave functions – Square wave, saw tooth wave and triangular wave.

Reference books

- Mathematical methods for physics sciences (3rd edition) - Mary. L. Boas
- First Chapter (Vector analysis) in Introduction to Electrodynamics (3rd edition) – David. J. Griffiths
- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier

GOVERNMENT COLLEGE (AUTONOMOUS), RAJAHMUNDRY
DEPARTMENT OF PHYSICS

I.B.Sc-MATERIAL SCIENCE

SEMESTER – I

COURSE 2: MECHANICS AND PROPERTIES OF MATTER

BSc Single Major Materials Science 2025-26 onwards

Theory Credits: 4 3 hrs/week

Course Objective

To provide a strong foundation in mechanics, elasticity, and fluid dynamics by studying the motion of particles, forces, and material behavior, and to relate these fundamental principles to the mechanical properties of materials.

Learning Outcomes

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

1. Apply Newton's laws and conservation principles to particle motion and collisions.
2. Explain motion under central forces and describe satellite dynamics.
3. Analyze the elastic behavior of solids and determine elastic constants.
4. Explain the bending of beams and torsional oscillations with applications to real systems.
5. Apply fluid dynamics concepts such as Bernoulli's principle, viscosity, and surface tension to practical problems.

Unit I: Mechanics of Particles (9 hrs)

Newton's laws of motion – applications. Motion of variable mass system – equation of a rocket. Conservation of energy and momentum. Collisions in two and three dimensions. Concept of impact parameter, scattering cross-section. Rutherford scattering – derivation.

Unit I: Central Forces and Planetary Motion (9 hrs)

Central forces – definition, examples, characteristics. Conservative nature of central forces. Force as negative gradient of potential energy. Equations of motion under central force. Derivation of Kepler's laws. Motion of satellites – escape and orbital velocity. Geostationary satellites – applications.

Unit III: Elasticity – Basics and Applications (9 hrs)

Stress and strain. Hooke's law. Elastic moduli: Young's, Bulk, and Shear modulus. Poisson's ratio – physical meaning and significance. Elastic energy – work done in stretching a wire. Twisting a couple on a cylinder. Applications of elasticity in material design (springs, structural materials).

Unit IV: Bending of Beams and Torsion (9 hrs)

Bending of beams – types of loads, point and distributed load. Cantilever bending – theory and applications. Uniform bending – theory and applications. Beam supported at both ends and loaded at the middle. Torsional pendulum – principle, working, and uses. Rigidity modulus from torsion experiments. Practical importance: bridges, shafts, machine components.

Unit V: Fluid Mechanics (9 hrs)

Fluids – properties and classification. Streamline vs turbulent flow. Reynolds number – significance. Equation of continuity – concept. Bernoulli's theorem – statement, derivation, and applications (Venturimeter, airplane lift). Viscosity – Poiseuille's law (statement and qualitative explanation). Surface tension – qualitative ideas and applications.

REFERENCE BOOKS

1. BSc Physics – Telugu Academy, Hyderabad
2. Mechanics – D.S. Mathur, S. Chand & Co., New Delhi
3. Mechanics – J.C. Upadhyaya, Ramprasad & Co., Agra
4. Properties of Matter – D.S. Mathur, S. Chand & Co., New Delhi, 11th Edition, 2009
5. Physics Vol. I – Resnick, Halliday & Krane, Wiley, 2001
6. Properties of Matter – Brijlal & Subrahmanyam, S. Chand & Co., 1982
7. Mechanics – E.M. Purcell, McGraw Hill
8. University Physics – F.W. Sears, M.W. Zemansky & H.D. Young, Narosa Publications, Delhi

SEMESTER-I

SKILL ENHANCEMENT COURSE 1: AI FUNDAMENTALS

Theory Credits:4 4hrs/week

Learning Objectives:

- Understand the history and evolution of Artificial Intelligence and Identify major subfields of AI.
- Investigate the role of AI in various industries like healthcare, agriculture, and education.
- Examine concepts like bias, fairness, transparency, and accountability in AI systems.
- Explore the integration of AI in scientific research and discuss future directions and evolving trends in AI.
- Learn how prompt engineering is used in various sectors like education and content creation.

Course Outcomes:

Students will be able to

- Describe the different subfields and their roles in AI applications.
- Analyze the benefits and limitations of AI in diverse domains.
- Evaluate AI systems in terms of inclusivity, privacy, and robustness.
- Describe Generative AI and emerging technologies like ChatGPT.
- Apply prompt engineering concepts to various real-world use cases.

Unit I. AI and its Subfields

Introduction to Artificial Intelligence, History, Definition, Artificial General Intelligence, Industry Applications of AI, Challenges in AI. Knowledge Engineering, Machine Learning, Computer Vision, Natural Language Processing, Robotics.

Unit 2. Applications of AI

Healthcare, Finance, Retail, Agriculture, Education, Transportation.

Unit 3. Bias and Fairness in AI Systems

Ethics in AI, Bias and Fairness in AI Systems, Transparency in AI Systems, Accountability, Security, Privacy, Inclusivity, Sustainability, Robustness, Reliability.

Unit 4. AI in Research, Generative AI and prompt engineering

AI in Experimentation and Multi-disciplinary research, Generative AI introduction, ChatGPT, Hugging Face, Gemini and other tools basics, Perplexity, Prompt engineering Definition and its importance, Role of Prompt Engineering in AI/ML Interaction, Emerging trends and Future Directions in AI.

Unit 5. Applications of Prompt engineering

Applications of Prompt Engineering: Education, Business & Commerce, Content Creation: AI for Creative Writing,AI for creative design, writing AI scripts for video, generating slides and slidesGPT usage, Designing thumbnails and channel branding with AI

Text Books:

AI for Everyone: A Beginner's Handbook for Artificial Intelligence (AI) by Saptarsi Goswami, Amit Kumar Das , Amlan Chakrabarti Prompt Engineering for Beginners: by Kapila Arora, Geetu Garg, Gaurav Arora.

References:

Let’s Learn Artificial Intelligence: Base Module, Niti Ayog, Atal Innovation Mission.

Prompt Engineering for Generative AI: Future-proof inputs for Reliable AI-outputs by James Phoenix & Mike Taylor.

Generative AI Tutorial:https://www.w3schools.com/gen_ai/

Generative AI 360°: Practical Guide to ChatGPT, Midjourney & AI Tools to Boost Productivity & Creativity , For Professionals, Marketers & Entrepreneurs by Hitesh Motwani , ZebraLearn, 2025.

Generative AI: Prompt Engineering Basics:

Learn Generative AI Prompt Engineering for everyone. https://www.coursera.org/learn/generative-ai-prompt-engineering-for-everyone?action=enroll

Free Artificial Intelligence (AI) Tutorial - Hands-On Prompt Engineering for AI Beginners & Business User | Udemy,

https://www.udemy.com/course/prompt-engineering-for-ai-beginners-business-users

GOVERNMENT COLLEGE (A), RAJAHMUNDRY

DEPARTMENT OF PHYSICS
SEMESTER-II (SYLLABUS)

COURSE-3: WAVES AND OPTICS

Theory Credits: 3 3 hrs. /week

COURSE OBJECTIVE:

The course aims to develop a foundational understanding of oscillatory motion, wave behavior in strings and bars, and optical phenomena like interference, diffraction, and polarization. Students will learn to mathematically analyze vibrations and light behavior through theoretical and experimental approaches.

LEARNING OUTCOMES:

On successful completion of this course, the students will be able to:

1. Describe the basic characteristics of waves such as frequency, wavelength, amplitude, period, and speed and utilize mathematical relationships related to wave characteristics.
2. Distinguish between Longitudinal and Transverse waves.
3. Understand the phenomenon of interference of light and its formation in Thin films and Newton's rings.
4. Distinguish between Fresnel's diffraction and Fraunhoffer diffraction and observe the diffraction patterns in the case of single slit and the diffraction grating and to describe the construction and working of zone plate and make the comparison of zone plate with convex lens
5. Explain the various methods of production of plane, circularly and polarized light and their detection and the concept of optical activity.

UNIT-I: SIMPLE HARMONIC, DAMPED & FORCED OSCILLATIONS (9 Hrs.)

Simple Harmonic Oscillator: Solution of differential equation, and physical characteristics, Principle of superposition - Damping, Damped Harmonic Oscillator: Solution of differential equation, Energy considerations, Logarithmic decrement, relaxation time, quality factor - Forced Oscillations: Solution of differential equation.

UNIT-II VIBRATING STRINGS AND BARS (9 hrs)

Transverse wave propagation along a stretched string - Velocity of transverse wave along a stretched string - Laws transverse vibrations of string - Longitudinal vibrations in bars - wave equation and its general solution. Special cases (i) bar fixed at both ends (ii) bar fixed at the midpoint (iii) bar fixed at one end - Tuning fork.

UNIT-III: INTERFERENCE (9 hrs)

Principle of superposition – coherence Conditions for interference of light - Fresnel's biprism: determination of wavelength of light – colors of thin films- Determination of diameter of wire - Newton's rings in reflected light: Determination of wavelength of monochromatic light using Newton's rings.

UNIT-IV: DIFFRACTION (9 hrs.)

GOVERNENT COLLEGE (A), RAJAHMUNDRY

DEPARTMENT PF PHYSICS

B.Sc. Physics – II Semester

Mandatory Audit Course

INDIAN KNOWLEDGE SYSTEMS FOR PHYSICAL SCIENCES

Course Type: Mandatory Audit Course Credits: 0 (Audit)

Hours per Week: 2 Total Teaching Hours: 30

Course Outcomes

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

CO1 (Unit I): Explain the scientific foundations of Indian Knowledge Systems including concepts of matter, cosmology and early atomic ideas.

CO2 (Unit II): Describe major Indian contributions to astronomy and mathe- matics relevant to physical sciences.

CO3 (Unit III): Analyze traditional Indian material technologies and logical sys- tems using modern scientific perspective.

UNIT I (10 Hours)

Scientific Foundations in Ancient India

Sources of Indian scientific knowledge – Vedas, Vedangas and Gurukula system.

Concept of matter – Panchabhuta theory.

Paramanu theory and Vaisheshika school of atomism.

Concepts of time, cosmology and cyclic universe.

Early scientific thinkers and their contributions.

UNIT II (10 Hours)

Indian Astronomy and Mathematical Physics

Development of astronomy in ancient India.

Concept of Earth’s rotation and planetary motion.

Methods of eclipse calculations.

Development of zero and place value system.

Trigonometry in astronomical measurements.

Infinite series and approximation methods (Kerala School).

UNIT III (10 Hours)

Indian Material Science, Engineering and Scientific Method

Ancient Indian metallurgy – Wootz steel and zinc distillation.

Corrosion resistance – Iron Pillar case study.

Temple architecture and structural engineering principles.

Water management and urban planning in Indus Valley Civilization.

Nyaya system – Pramana and logical reasoning.

Reference Books

B.V. Subbarayappa, Science in India: A Historical Perspective.

Debiprasad Chattopadhyaya, History of Science and Technology in Ancient India.

Kapil Kapoor, Indian Knowledge Systems.

UGC, Indian Knowledge Systems – Introductory Module.

GOVERNENT COLLEGE (A), RAJAHMUNDRY
DEPARTMENT PF PHYSICS

APPLICABLE TO MATHEMATICS, PHYSICS, CHEMISTRY AND ANY OTHER MATHEMATICAL SCIENCES
SEMESTER-II
SKILL ENHANCE COURSE 1: APPLICATIONS OF ARTIFICIAL INTELLIGENCE

Theory Credits: 3 3 hrs/week

Course Objectives

- Provide a foundational understanding of AI platforms, data pipelines, and their importance in the physical sciences.
- Introduce real-world datasets and public repositories relevant to physics, chemistry, mathematics, and earth sciences.
- Explain how AI is applied to solve scientific problems, discover patterns, and support research in physical sciences in a simple, non-coding manner.
- Highlight ethical concerns, data challenges, and the future of AI-driven discoveries in physical sciences.

Course Outcomes

- On successful completion of this course, students will be able to:
- Explain the AI ecosystem (hardware, cloud, and edge devices) in relation to physical sciences applications.
- Identify scientific data types and public repositories relevant to physics, chemistry, mathematics, and earth sciences.
- Describe the process of preparing and managing scientific data pipelines.
- Illustrate the role of AI in solving real-world scientific challenges in physics, chemistry, mathematics, and earth sciences.
- Analyze ethical, environmental, and societal impacts of AI-driven scientific applications.

SYLLABUS

Unit 1. Infrastructure and Platforms for Building Applications using AI

Hardware used in building AI applications: Processors - CPU, GPU, TPU, NPU, Memory - RAM, VRAM, Storage - HDD, SSD. Platforms for building applications using AI: Online platforms (Example - Google AutoML, H2O.ai, Teachable Machine or similar platforms - for practice only); Desktop (No-code/Low- code) platforms (Orange Data Mining, KNIME, Weka, RapidMiner or similar tools - for practice only).

Edge AI: Concept; Applications in daily life in devices like Refrigerators, Led Bulbs, Surveillance Cameras, Micro Ovens, Smart Cars/Scooters; Edge AI in smart Appliances

Unit 2: Foundations of Data - Types,

Ethics and Utility in Building Applications using AI Importance of data in building AI applications: Data as the fuel for AI, Role of big data in training AI models.

Conceptual Foundations of Data: Data vs. Information vs. Knowledge.

Structure of Data: Structured, Semi-Structured, and Unstructured Data.

Modalities of Data: Text, Image, Audio, Video, Tabular, Time-Series, and Spatial Data. Formats of Data: Text Formats (CSV, JSON, XML), Image Formats (JPEG, GIF, PNG), Audio/Video (MP3, WAV, MP4, AVI).

Data Repositories: Definition of public Datasets; Definition of private Datasets; Importance of Public Datasets, Popular Public Dataset Repositories (Example - Kaggle, Hugging Face Datasets, UCI Machine Learning Repository, Google Dataset Search or similar ones - for demonstration only), Dataset licensing and usage rights.

Ethics, Privacy in Data Usage: Privacy concerns related to data usage; Regulations governing data usage - GDPR, HIPAA (Overview), Ethical use of data, Responsible AI data practices.

Unit 3. The AI Data Pipeline: From Collection to Model Readiness

The AI Data Pipeline: Stages and Components: Key Stages (Data Collection, Annotation, Preprocessing, Splitting, Feeding into AI Models

Core Components: Ingestion, Storage, Processing, Validation, Delivery

Data Collection Methods for AI: Manual Input (Surveys, forms, human-curated entries), Sensors & IoT Devices (Real-time data from physical environments), System Logs & Transactions, Web Scraping (Automated extraction from websites), APIs (Structured data access from external platforms)

Data Annotation and Labelling: Definition & Importance; Annotation Methods: Manual Annotation, Automated Annotation; Types of Annotation: Classification, Bounding Boxes, Segmentation, Transcription, Named Entity Recognition (NER)

Data Cleaning and Preprocessing: Importance of data cleaning; Understanding “Dirty” Data: Missing Values, Duplicates, Incorrect Formats, Outliers, Noise; Steps in Data Cleaning: Identify Issues, Handle Errors (Imputation, Removal), Validate Cleaned Data

Data Splitting: Splitting data into training set and test set.

Data Transformation Techniques: Normalization, Transformation, Feature Engineering (Conceptual)

Unit 4: AI in Physical Sciences (Physics & Chemistry Applications)

AI in Physics: AI for analyzing astronomical images (identifying galaxies, stars, exoplanets), CERN Datasets for Particle Physics.

AI in material science: discovering new superconductors and quantum materials AI in energy: predicting power grid loads, optimizing solar and wind energy systems

AI in Chemistry:Protein structure prediction (AlphaFold). AI in drug discovery - virtual screening of compounds. AI in chemistry - reaction outcome & material property prediction.

Unit 5: AI in Mathematics and Earth Sciences

Pattern recognition in large datasets (fractals, chaos systems, number theory) Automated theorem proving and symbolic mathematics

AI in optimization problems (transport, logistics, resource allocation)

(Explore the Wolfram Alpha Tool: https://www.wolframalpha.com/examples/mathematics)

Climate modeling: AI predicting weather patterns, cyclones, and long-term climate change Remote sensing: AI analyzing satellite images for deforestation, urbanization, and natural resource mapping

Earthquake and natural disaster prediction using sensor networks

AI in geology: identifying mineral deposits, oil, and groundwater reserves

GOVERNENT COLLEGE (A), RAJAHMUNDRY
DEPARTMENT PF PHYSICS
Multidisciplinary Course
I.BSc. MATEIAL SCIENCE-- SEMESTER-II
INDIAN HISTORY

Credits: 2 **2 hrs/week**

Learning Outcomes:

After successful completion of this course, the student will be able to:

- Students will have an overall understanding of Indian history and culture from ancient to modern India.
- Learn about the changes in society, economy, politics, and culture under various dynasties.
- Know mediaeval Indian history and culture.
- Understand the greatness of the Mughals and their administration.
- Visualise how the Europeans are settled and how the colonials introduce various economic policies and their impacts.Know the stages of the Indian Freedom Struggle and the roles of Gandhi and Subash Chandra Bose.

Syllabus:

Unit-I

Ancient Indian History and Culture: What is History-Evolution of Man-Science and Technology in Harappan Civilisation-Vedic Literature- Difference between Jainism and Buddhism

Philosophy-Ashoka Dhamma Policy-Science and Technology in Guptha Period Chronology of Various Dynasties that ruled India (6th Century BC to 1206 CE)

Unit-II

History and Culture of Medieval India: Delhi Sultanate: Rulers (Brief), Alla-Ud Din-Khilji and Muhammad-Bin-Tuglaq Reforms-Greater Mughals (Brief)-Mughal Administration-Akbar Religious Policy-Mughal Art and Architecture-Bhakti Saints

Unit-III

History of Modern India: European Settlements-British Revenue Policies-Economic Impact of British Rule-Socio-Religious Reform Movements-Causes for 1857 Revolt-Indian Freedom Struggle: Vandemataram, Home Rule Movement-Gandhi's Role: Non-Cooperation Movements, Salt Satya Graha and Quit India Movement-Subash Chandra Bose-Partition of India.

Curricular Activities:

- Map-pointing/Collection of Historical news paper cuttings.
- Prepare a chart on Ancient, Medieval Dynasties and their rulers.
- Collect the various National Leaders photographs
- Prepare a list of Historical events in chronological order
- Unit Tests/Quiz/Debates/Workshops/Book Reviews/Seminars/Assignments.
- Collection of Articles and Books/Preparation of Videos/Charts
- Photos Exhibitions on Historical Importance/Visit to the Museums

References:

1. E.H. Carr., What is History, Penguin, 1961

2. R.S.Sharma., Ancient India, New Delhi, 1996

3. D.N.Jha, Ancient India: In Historical Outline, Manohar Publishers, 1999.

4. R.C.Majumdar, K.K.Dutta &H.C.Roy Chowdhuri (ed.), An Advanced History of India, Macmillan, 1948.

5. Romila Thapar., Early India: From the origins to 1300, University of California Press, 2004.

6. Ranabir Chakravarthi., Exploring Early India, upto 1300 A.D, Primus Books, 2016.

7. Satish Chandra., History of Medieval India, 800-1700, Oriental Blackswan, 2007.

8. Satish Chandra., Medieval India: From Sultanate to the Mughals, Part-I & II, Har Anand Publications, 2005.

9. I.H.Qureshi., The Administration of the Sultanate of Delhi, Oriental Books, 1977.

10. Harbans Mukhia., The Mughals of India, Wiley Publishers, 2008.

11. JhanF.Richards., The Mughal Empire, All Volumes, Cambridge University Press, 2012.

12. Sumit Sarkar., Modern India, Pearson India, 2014.

13. Śekhara Bandyopādhyāẏa.,From Plessey to Partition: A History of Modern India, Oriental Blakswan, 2004

14. V.D.Mahajan., Modern Indian History, S.Chand and Company Limited, 2020.

15. Bipan Chnadra, A.Tripathi, Barunde., Freedom Struggle, National Book Trust, 1987.

16. R.C.Dutt., The Economic History of India Under Early British Rule, K.Paul, Trench, Trubner& Company Limited, 2008.

17. Tirthankar Roy., How British Rule Changed India’s Economy: The Paradox of the Raj, Springer International Publishing, 2020.

18. S.N.Sen., An Advanced History of Modern India, Macmillan India, 2010.

19. Ishita Banerjee-Dube., A History of Modern India, Cambridge University Press, 2015

GOVERNENT COLLEGE (A), RAJAHMUNDRY
DEPARTMENT PF PHYSICS
I.B Sc –MATEIAL SCIENCE
Multidisciplinary Courses Offered for B.A./B.Com./BBA/BCA Majors
w.e.f. AY 2023-24
SEMESTER-II
PRINCIPLES OF PHYSICAL SCIENCES

Credits: 2

2 hrs/week

Course Objective:

The course "Principles of Physical Sciences " is designed to introduce arts students to fundamental concepts and principles of physical sciences, fostering a deeper understanding of the physical world and its interconnections with various disciplines.

Learning outcomes:

Upon completion of the course "Principles of Physical Sciences for Arts Students," students from arts backgrounds will be able to:

1. Understand the foundational principles of physical sciences: Students will develop a comprehensive understanding of the core principles and concepts in physical sciences.

2. Analyse and interpret scientific information: Students will acquire the ability to critically analyse scientific information and data related to physical sciences.

3. Apply physical science principles to real-world scenarios: Students will develop the skills to apply physical science principles to solve real-world problems and scenarios.

Syllabus:

Unit 1: Introduction to Physics

Nature of Physics: Overview of physics as a discipline, its scope, and its relationship to other sciences. Scientific Method in Physics: Introduction to the scientific method and its application in the study of physics. Measurement and Units: Understanding the principles of measurement, SI units, and the importance of accurate and precise measurements. Scalars and Vectors: Differentiating between scalars and vectors, understanding vector addition and subtraction.

Unit 2: Mechanics for Arts Students

Motion and Forces: Introduction to the principles of motion, including velocity, acceleration, and the laws of motion. Energy and Work: Understanding the concept of energy, different forms of energy, and the relationship between work and energy. Circular Motion: Exploring the principles of circular motion, centripetal force, and applications in real-world scenarios. Gravity: Introduction to the concept of gravity, Newton's law of universal gravitation, and its implications.

Unit 3: Waves and Optics for Arts Students

Waves: Understanding the properties and characteristics of waves, including wave types, wave motion, and wave interference. Sound Waves: Exploring the nature of sound waves, including properties of sound, sound propagation, and the Doppler effect. Light and Optics: Introduction to the behavior of light, reflection, refraction, and the formation of images by mirrors and lenses. Wave Optics: Understanding the principles of interference, diffraction, and polarization of light waves.

Reference Books:

1."Principles of Physics" by David Halliday, Robert Resnick, and Jearl Walker: This textbook covers the fundamental principles of physics, including mechanics, electromagnetism, thermodynamics, and modern physics. It provides a comprehensive introduction to the subject and includes numerous examples and exercises for practice.

2. "University Physics" by Hugh D. Young and Roger A. Freedman: This textbook is widely used in university-level physics courses. It covers a wide range of topics in classical physics, modern physics, and thermodynamics. It is known for its clear explanations and problem-solving approach.

3. "Concepts of Modern Physics" by Arthur Beiser: This book provides an introduction to the principles and concepts of modern physics, including quantum mechanics, atomic and nuclear physics, and relativity. It is suitable for students with a basic background in physics and mathematics.

4. "The Feynman Lectures on Physics" by Richard P. Feynman, Robert B. Leighton, and Matthew Sands: This three-volume set is based on the famous lectures given by physicist Richard Feynman. It covers a wide range of topics in physics, including mechanics, electromagnetism, quantum mechanics, and statistical mechanics. The lectures are known for their engaging style and intuitive explanations.

5. "Physical Science" by Bill Tillery: This textbook provides a comprehensive introduction to the principles of physical science, covering topics such as motion, forces, energy, waves, electricity, and magnetism. It is designed for introductory-level courses and includes numerous examples, illustrations, and practice problems.

6. "Fundamentals of Physics" by Jearl Walker, David Halliday, and Robert Resnick: This textbook is widely used in physics courses and covers the fundamental principles of classical physics. It includes a strong emphasis on problem-solving and conceptual understanding.

Student activities:

1. Conduct research on a famous physicist or a significant discovery in the field of physics. Write a short report highlighting the physicist's contributions or explaining the importance of the discovery. Include information about how the discovery impacted other scientific fields or technological advancements.

2. Watch videos or animations demonstrating circular motion, such as the motion of objects on a Ferris wheel or a car turning on a curved track. Identify the forces involved, including the centripetal force, and explain how they contribute to the object's circular motion. Discuss real-world examples where circular motion is significant, such as satellites orbiting the Earth.

3. Set up a wave demonstration using a rope or a slinky to visualize the properties of waves, such as wavelength, frequency, amplitude, and wave speed. Observe how these properties change when altering the parameters of the wave, such as tension or length.

SEM-III	Course Code	Title of the Course	L	T	P	C
	5	CRYSTALLOGRAPHY AND CRYSTAL STRUCTURES	3	0	0	3
	Prerequisites					

Course Objectives:

To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can withstand catastrophic failures in different environments, and also a fundamental understanding of electrical, magnetic and optical properties of materials and to apply those fundamentals for selecting and developing materials for different engineering applications.

Course Outcomes:

On Completion of the course, the students will be able to-	
CO1	Understand the fundamental concepts of crystallography and crystal structures.
CO2	Apply X-ray diffraction techniques to analyze crystal structures.
CO3	Identify and characterize various types of crystal defects.
CO4	Use electron and neutron diffraction methods to study material properties.
CO5	Interpret and analyze phase transitions in crystalline materials.

Syllabus

UNIT -I **(9 hrs)**

Fundamentals of Crystallography: Crystalline and Amorphous solids, Crystal Systems- Bravias Structures- Two dimensional and three dimensional Lattice Types - Symmetry Elements and Operations - Miller Indices and Planes – Simple Crystal Structures- NaCl and CsCl structures.

Activity Proposed: Classification of Crystal systems and defects
Evaluation Method: Study report

UNIT –II **(9 hrs)**

X-ray Diffraction: Principles of X-ray Generation - Bragg's Law and Diffraction Patterns - X-ray Diffraction Techniques: Powder and Single Crystal Methods - Analysis of Crystal Structures - Applications of X-ray Diffraction

Activity Proposed: Applications of X-Ray diffraction

Evaluation Method: Assignment

Unit-III: (9 hrs)

Electron and Neutron Diffraction: Basics of Electron Diffraction – Davison Germer Experiment, Comparison with X-ray Diffraction - Neutron Diffraction: Principles and Techniques - Applications in Material Science.

Activity Proposed: preparation of models
Evaluation Method: Demonstration

Unit IV: (9 hrs)

Defects in Crystals: Types of Defects: Point, Line, Planar - Role of Defects in Material Properties - Techniques for Studying Defects - Impact on Mechanical and Electrical Properties - Grain Boundaries and Their Effects

Activity Proposed: Preparation of Glasses
Evaluation Method: Lab report

Unit V: (9 hrs)

Crystal Growth and Applications: Basic concepts of crystal growth – Importance and fundamental principles. Methods of Crystal growth – Solution (Slow evaporation method) and melt (Czochralski and Bridgman) techniques. Importance of crystal growth in materials science. Applications of Crystal growth.

Activity Proposed: Presentation on synthesis of nanomaterials
Evaluation Method: Content, Demonstration

Text Books:

"Introduction to Solid State Physics" by Charles Kittel

Reference books:

1. Elements of X-ray Diffraction by B.D. Cullity and S.R. Stock
2. Introduction to Solid State Physics by Charles Kittel
3. Fundamentals of Crystallography by C. Giacovazzo
4. X-Ray Diffraction: A Practical Approach by C.S. Barrett and T.B. Massalski
5. Crystallography: An Introduction by Walter Borchardt-Ott

SEM-III	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**C**
	6	**Thermodynamics and Kinetics of Materials**	3	0	0	3
	Prerequisites					

Course Objectives:

1. To study the basics of mechanical properties of materials.
2. The course deals with the crystal imperfections, diffusion in solids, elastic behaviour of

Course Outcomes:

On Completion of the course, the students will be able to-	
CO1	Understand the principles of thermodynamics and their application to materials science.
CO2	Interpret and construct phase diagrams for unary and binary systems.
CO3	Analyze the kinetics of diffusion and phase transformations in materials.
CO4	Apply statistical thermodynamics to understand material behavior.
CO5	Utilize thermodynamic and kinetic principles to solve material science problems.

Syllabus

Unit I 9 hours

Thermodynamic Principles: Laws of Thermodynamics - State Functions: Internal Energy, Enthalpy, Entropy - Gibbs free energy and Chemical Potential - Thermodynamic Equilibrium - Applications in Material Science

Activity Proposed: Classification of metals and alloys

Unit II **9** hours

Phase Diagrams: Unary Phase Diagrams - Binary Phase Diagrams and Lever Rule - Ternary Phase Diagrams - Eutectic and Peritectic Reactions - Phase Transformations

Activity Proposed: Classification of metals and alloys

Unit III **9** hours

Statistical Thermodynamics: Basics of Statistical Mechanics - Distribution Functions: Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein - Partition Function and Thermodynamic Properties - Applications to Solids and Gases - Thermodynamic Models

Activity Proposed: Classification of metals and alloys

Unit IV **9** hours

Kinetics of Materials: Diffusion: Fick's Laws, Mechanisms - Nucleation and Growth Kinetics - Solid-State Reactions - Rate Theories: Arrhenius Equation, Transition State Theory - Applications in Material Processing

Activity Proposed: Classification of metals and alloys

Unit V **9** hours

Thermodynamics and Kinetics in Advanced Materials: Thermodynamics of Surfaces and Interfaces - Phase Field Modeling - Kinetics in Nanomaterials - Thermodynamics in Biological Materials - Case Studies and Current Research

Activity Proposed: Classification of metals and alloys

Text Books:

"Thermodynamics in Materials Science" by Robert DeHoff

1. "Thermodynamics in Materials Science" by Robert DeHoff
2. "Introduction to the Thermodynamics of Materials" by David R. Gaskell
3. "Phase Transformations in Metals and Alloys" by David A. Porter and Kenneth E. Easterling
4. "Physical Chemistry of Metals" by L.S. Darken and R.W. Gurry
5. "Kinetics of Materials" by Robert W. Balluffi, Samuel M. Allen, and W.C. Carter

SEM-III	Course Code	Title of the Course	L	T	P	C
	7	**Mechanical Properties of Materials**	3	0	0	3
	Prerequisites					

Course Objectives:

1. To study the basics of properties of nanomaterials.
2. The course deals with the crystal imperfections, diffusion in solids, elastic behaviour of materials, plastic deformation and fracture, etc.
3. Students should be able to classify various types of defects in the materials and their connection with elastic/plastic deformations and various mechanical properties of materials.
4. This would help students in the selection of materials for various applications during their career.

Course Outcomes:

On Completion of the course, the students will be able to-	
CO1	Understand the stress-strain behavior of materials and their mechanical properties.
CO2	Conduct mechanical tests to determine material properties such as hardness, toughness, and fatigue.
CO3	Analyze the effects of microstructural changes on mechanical properties.
CO4	Apply principles of fracture mechanics to predict material failure.
CO5	Understand the mechanisms of material strengthening and apply them to improve material performance.

Syllabus

UNIT-I **(9 hrs)**

Introduction to Mechanical Properties: Stress and Strain Relationships - Elastic Deformation: Young's Modulus, Poisson's Ratio - Plastic Deformation: Yield Strength, Hardening - True Stress and True Strain - Mechanical Testing Methods

Activity Proposed:

Evaluation Method: Study report

UNIT-II **(9 hrs)**

Fracture Mechanics: Types of Fracture: Ductile and Brittle - Fracture Toughness and Crack Propagation - Fatigue: S-N Curves, Fatigue Life - Creep: Creep Curves, Creep Mechanisms - Failure Analysis

Activity Proposed:

Evaluation Method: Study report

UNITS-III **(9 hrs)**

Strengthening Mechanisms: Work Hardening and Cold Working - Grain Boundary Strengthening: Hall-Petch Relationship - Solid Solution Strengthening - Precipitation and Age Hardening - Case Studies in Strengthening Techniques

Activity Proposed:

Evaluation Method: Study report

UNIT-IV **(9 hrs)**

Mechanical Properties of Specific Materials: Metals: Ferrous and Non-Ferrous Alloys - Ceramics: Brittle Behavior, Toughening Mechanisms - Polymers: Viscoelasticity, Deformation Behavior - Composites: Fiber and Matrix Materials - Biomaterials: Mechanical Properties and Applications

Activity Proposed:

Evaluation Method: Study report

UNIT-V **(9 hrs)**

Applications and Case Studies: Mechanical Properties in Design - Structural Materials in Aerospace and Automotive Industries - Wear and Tear in Industrial Applications - Biomechanics: Implants and Prosthetics - Future Trends and Research Directions

Activity Proposed:

Evaluation Method: Study report

Text Books:

1. Mechanical Behavior of Materials; by Norman E. Dowling
2. Mechanical Metallurgy; by George E. Dieter
3. Mechanical Properties of Solid Polymers; by I.M. Ward and J. Sweeney
4. Deformation and Fracture Mechanics of Engineering Materials; by Richard W. Hertzberg
5. Mechanical Properties of Materials; by William D. Callister and David G. Rethwisch

II B.Sc-MATERIAL SCIENCE SEM-III	Course Code	Title of the Course	L	T	P	C
	COURSE: 8	**Electrical and Magnetic Properties of Materials**	3	0	0	3
	Prerequisites					

Course Objectives:

This course aims to provide the basic concepts of heat and dynamics of a substance under various thermodynamics conditions as a sound background in thermodynamics is necessary for understanding materials. The nature of bonding, energy and structure of various metal complexes based on coordination principles are also imparted.

Course Outcomes:

On Completion of the course, the students will be able to-	
CO1	Understand the electrical properties of conductors, semiconductors, and insulators.
CO2	Analyze the magnetic properties of materials and their applications.
CO3	Measure and interpret the dielectric properties of materials.
CO4	Understand the principles of superconductivity and its applications.
CO5	Apply knowledge of electrical and magnetic properties to material design and selection.

Syllabus

Unit 1 **9 hours**

Fundamentals of Electrical Properties: Conductivity and Resistivity - Ohm’s Law and Electrical Circuits - Band Theory of Solids - Intrinsic and Extrinsic Semiconductors - Temperature Dependence of Conductivity

Unit II **9 hours**

Semiconductor Physics: p-n Junctions and Diodes - Transistors: Bipolar Junction and Field-Effect Transistors - Semiconductor Devices: LEDs, Photovoltaics - Carrier Generation and Recombination - Doping Techniques and Applications

Unit III **9 hours**

Magnetic Properties: Basic Concepts: Magnetic Moments, Susceptibility - Types of Magnetism: Diamagnetism, Paramagnetism, Ferromagnetism - Magnetic Domains and Hysteresis - Magnetic Materials: Soft and Hard Magnets - Applications: Data Storage, Transformers, and Magnetic Sensors

Unit IV **9 hours**

Dielectric Properties: Polarization Mechanisms: Electronic, Ionic, Orientation - Dielectric Constant and Loss - Ferroelectric and Piezoelectric Materials - Dielectric Materials in Capacitors - Applications in Electronics and Communication

Unit V **9 hours**

Superconductivity and Advanced Topics: Basics of Superconductivity - Type I and Type II Superconductors - BCS Theory - Applications of Superconductors: MRI, Power Cables - Emerging Trends in Electrical and Magnetic Materials

Text Books:

"Electronic Properties of Materials" by Rolf E. Hummel

1. Electronic Properties of Materials; by Rolf E. Hummel
2. Solid State Physics; by S.O. Pillai
3. Introduction to Magnetic Materials; by B.D. Cullity and C.D. Graham
4. Electrical Properties of Materials; by L. Solymar and D. Walsh
5. Magnetic Materials: Fundamentals and Applications; by Nicola A. Spaldin

GOVERNMENT COLLEGE (A) :: RAJAMAHENDRAVARAM
DEPARTMENT OF PHYSICS
II B.Sc. Material Science SEMESTER-IV
(w.e.f. 2023-24)
COURSE 9: Characterization Techniques in Material Science

Unit 1: Optical Microscopy (9 hours)

1.1 Principles of Light Microscopy: Basic components of an optical microscope, Magnification and resolution 1.2 Bright Field and Dark Field Microscopy: Differences and applications, Techniques for enhancing contrast, Practical applications in material science 1.3 Phase Contrast and Polarized Light Microscopy: Principles and applications of phase contrast microscopy, Use of polarized light for studying birefringent materials, Applications in mineralogy and polymer science 1.4 Applications in Material Analysis: Identification of microstructures, Study of grain boundaries and phase distributions, Failure analysis and defect identification

Unit 2: Electron Microscopy (9 hours)

2.1 Scanning Electron Microscopy (SEM): Principles of SEM, Applications in surface morphology analysis 2.2 Transmission Electron Microscopy (TEM): Principles of TEM, Imaging and diffraction modes, Applications in crystallography and defect analysis 2.3 Sample Preparation for Electron Microscopy: Techniques for preparing thin samples for TEM, Coating techniques for SEM, Cryo-preparation methods for biological samples 2.4 Advanced Electron Microscopy Techniques: High-resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM), Electron energy loss spectroscopy (EELS)

Unit 3: Spectroscopy Techniques (9 hours)

3.1 X-ray Spectroscopy: X-ray photoelectron spectroscopy (XPS), Energy-dispersive X-ray spectroscopy (EDS), Applications in elemental analysis and surface chemistry 3.2 Raman Spectroscopy: Principles of Raman scattering, Raman instrumentation and techniques, Applications in material identification and stress analysis 3.3 Infrared Spectroscopy (FTIR): Principles of infrared absorption, Fourier transform infrared (FTIR) spectroscopy, Applications in functional group identification and polymer analysis 3.4 UV-Vis Spectroscopy: Principles of UV-Vis absorption, Instrumentation and techniques, Applications in band gap determination and color analysis 3.5 Nuclear Magnetic Resonance (NMR) Spectroscopy: Principles of NMR, Chemical shift and spin-spin coupling, Applications in structural analysis of organic and inorganic compounds

Unit 4: Thermal Analysis Techniques (9 hours)

4.1 Differential Scanning Calorimetry (DSC): Principles and operation of DSC, Measurement of thermal transitions Tg, and Tm, Applications in polymer and pharmaceutical analysis 4.2 Thermogravimetric Analysis (TGA): Principles and operation of TGA, Measurement of weight loss and decomposition temperatures, Applications in material stability and composition analysis 4.3 Differential Thermal Analysis (DTA): Principles and operation of DTA, Comparison with DSC, Applications in phase transition analysis 4.4 Applications and Case Studies: Thermal analysis of composite materials, Study of thermal degradation and stability, Practical applications in quality control and research

Unit 5: Advanced Characterization Methods (9 hours)

5.1 Atomic Force Microscopy (AFM): Principles of AFM, Imaging modes: contact, tapping, non-contact, Applications in surface topography and force measurements 5.2 Scanning Tunneling Microscopy (STM): Principles of STM, Tunneling current and surface imaging, Applications in nanostructure analysis 5.3 X-ray Tomography: Principles of X-ray computed tomography (CT), Reconstruction and imaging techniques, Applications in non-destructive testing and 3D imaging 5.4 Surface Plasmon Resonance (SPR): Principles of SPR, Instrumentation and measurement techniques, Applications in biosensing and surface interactions 5.5 Current Trends and Innovations in Material Characterization: Advances in in-situ and operando techniques, Integration of multiple characterization methods, Future directions and emerging technologies.

GOVERNMENT COLLEGE (A) :: RAJAMAHENDRAVARAM
DEPARTMENT OF PHYSICS
II B.Sc. Material Science SEMESTER-IV
(w.e.f. 2023-24)
COURSE 10: Polymer science

CO1	Understand the basic concepts and types of polymers.
CO2	Synthesize and characterize polymers using various methods.
CO3	Analyze the thermal and mechanical properties of polymers.
CO4	Understand the applications of polymers in different fields.
CO5	Apply knowledge of polymer science to solve practical problems in material science.

Unit I (9 hours)
Basics of Polymer Science: Introduction to Polymers - Types of Polymers: Thermoplastics, Thermosets, Elastomers - Polymerization Mechanisms: Addition, Condensation - Molecular Weight and Distribution - Polymer Nomenclature and Classification

Unit II (9 hours)
Polymer Structure and Properties: Crystallinity in Polymers - Amorphous and Semi-Crystalline Polymers - Glass Transition Temperature - Mechanical Properties: Tensile, Impact, Hardness - Thermal Properties: Tm, Tg, Degradation

Unit III (9 hours)
Polymer Processing and Fabrication: Techniques: Extrusion, Injection Molding, Blow Molding - Film and Fiber Formation - Compounding and Blending - Additives and Reinforcements - Recycling and Sustainability

Unit IV (9 hours)
Advanced Polymer Systems: Conductive Polymers - Biodegradable Polymers - Polymer Nanocomposites - Smart Polymers and Hydrogels - Applications in Electronics, Medicine, and Packaging

Unit V (9 hours)
Characterization and Testing of Polymers: Spectroscopic Methods: FTIR, NMR, UV-Vis - Thermal Analysis: DSC, TGA - Mechanical Testing: Tensile, Impact - Rheology and Viscosity Measurements - Case Studies and Applications

Text Books:

1. Polymer Science and Technology; by Joel R. Fried
2. Introduction to Polymers; by Robert J. Young and Peter A. Lovell
3. Textbook of Polymer Science; by Fred W. Billmeyer Jr.
4. Principles of Polymer Chemistry; by Paul J. Flory
5. Polymer Chemistry: An Introduction; by Malcolm P. Stevens

17	What is a polymer nanocomposite? Name nanofiller used	IV	BL2 CLO4	PLO3	**3.1.2**
18	Define Differential Scanning Calorimetry (DSC) and mention one application	V	BL2 CLO5	PLO2	**2.2.1**

GOVERNMENT COLLEGE (A) :: RAJAMAHENDRAVARAM
DEPARTMENT OF PHYSICS
II B.Sc. Material Science SEMESTER-IV
(w.e.f. 2023-24)
COURSE 11: Ceramics and Composite Materials

Unit 1 (9 hours)
Fundamentals of Ceramic Materials: Introduction to Ceramics - Crystal Structures of Ceramics - Properties of Ceramics: Mechanical, Thermal, Electrical - Processing and Sintering of Ceramics - Applications in Industry

Unit 2 (9 hours)
Types of Ceramics and Their Properties: Traditional Ceramics: Clay, Silicates, Glasses - Advanced Ceramics: Oxides, Carbides, Nitrides - Bioceramics: Hydroxyapatite, Zirconia - Electroceramics: Dielectrics, Ferroelectrics, Piezoelectrics - Case Studies and Applications

Unit 3 (9 hours)
Introduction to Composite Materials: Definition and Classification - Matrix and Reinforcement Materials - Fabrication Methods: Hand Lay-Up, Filament Winding, Pultrusion - Mechanical Properties of Composites - Applications in Aerospace, Automotive, and Construction

Unit 4 (9 hours)
Types of Composites: Fiber-Reinforced Composites - Particle-Reinforced Composites - Structural Composites: Laminates, Sandwich Panels - Nanocomposites - Environmental and Cost Considerations

Unit 5 (9 hours)
Characterization and Testing of Ceramics and Composites: Mechanical Testing: Hardness, Strength, Toughness - Thermal and Electrical Testing - Microscopy: Optical, Electron - Non-Destructive Testing: Ultrasonics, X-ray - Applications and Current Research

Text Books:
"Ceramics: Mechanical Properties, Failure Behaviour, Materials Selection" by Dietrich Munz and Theo Fett
1. Introduction to Ceramics; by W.D. Kingery, H.K. Bowen, and D.R. Uhlmann
2. Fundamentals of Ceramics; by Michel W. Barsoum
3. Engineering Materials: Properties and Selection; by Kenneth G. Budinski and Michael K. Budinski
4. Composite Materials: Science and Engineering; by Krishan K. Chawla
5. Ceramic Materials: Science and Engineering; by C. Barry Carter and M. Grant Norton

GOVERNMENT COLLEGE (A) RAJAHMUNDRY

DEPARTMENT OF PHYSICS

III.BSc-Material Science. - Semester-VI,

COURSE 12: FUNDAMENTALS OF NANOMATERIALS

Course Objective:

To provide students with a comprehensive understanding of the principles, synthesis, characterization, and applications of nanomaterials, emphasizing their unique properties and potential in science and technology.

Learning Outcomes

1. Explain the fundamentals of nanoscience and nanotechnology.
2. Describe synthesis techniques and evaluate their advantages and limitations.
3. Apply basic principles of characterization methods to analyze nanomaterials.
4. Correlate unique nanoscale properties with applications.
5. Discuss ethical and safety aspects of nanotechnology.

Unit I: Introduction to Nanoscience and Nanotechnology (9 hrs)

Definition and scope of nanoscience and nanotechnology, Historical background and milestones

Classification of nanomaterials – zero, one, two, and three-dimensional, Quantum confinement, surface-to-volume ratio, size-dependent properties, Potential applications in physics, chemistry, biology, and engineering

Unit II: Synthesis of Nanomaterials (9 hrs)

Top-down and bottom-up approaches, Physical methods: Mechanical milling, lithography, vapor deposition, Chemical methods: Sol-gel, chemical vapor deposition, hydrothermal synthesis, Biological methods: Microbial and plant-mediated synthesis, Comparison of methods – advantages and limitations

Unit III: Characterization Techniques (9 hrs)

Optical microscopy and electron microscopy – SEM, TEM, Scanning probe microscopy – AFM, STM, X-ray diffraction (XRD) – basic principles and applications, Dynamic light scattering (DLS) for particle size analysis, Simple introduction to Raman and FTIR spectroscopy for nanomaterials

Unit IV: Properties of Nanomaterials (9 hrs)

Mechanical, electrical, optical, magnetic, and thermal properties, Quantum size effects

Carbon-based nanomaterials – fullerenes, carbon nanotubes, graphene, Metal and metal oxide nanoparticles – gold, silver, TiO_2, ZnO, Polymeric nanomaterials and nanocomposites

Unit V: Applications of Nanomaterials (9 hrs)

Nanomaterials in electronics, sensors, energy storage and conversion, Medical applications – drug delivery, imaging, diagnostics, Environmental applications – water purification, pollution control

Nanomaterials in textiles, cosmetics, and food industry, Ethical, environmental, and safety issues in nanotechnology

Reference Books

- C.N.R. Rao, A. Müller, A.K. Cheetham, The Chemistry of Nanomaterials, Wiley-VCH.
- Charles P. Poole, Frank J. Owens, Introduction to Nanotechnology, Wiley.
- M.S. Ramachandra Rao, Shubra Singh, Nanoscience and Nanotechnology, Wiley.
- T. Pradeep, Nano: The Essentials, McGraw-Hill

COURSE 12: FUNDAMENTALS OF NANOMATERIALS

LIST OF PRACTICALS

Laboratory Course (30 hrs, 10 Experiments)

1. Synthesis of silver nanoparticles by chemical reduction
2. Green synthesis of nanoparticles using plant extract
3. Preparation of ZnO nanoparticles (sol-gel)
4. Optical absorption study of nanoparticles (UV-Vis)
5. Grain size estimation using XRD data
6. Study of surface plasmon resonance of metal nanoparticles
7. Thin film preparation by spin coating
8. Electrical conductivity of nanoparticle pellet
9. SEM/TEM image interpretation (demo/case study)
10. Mini-project on nanotechnology applications

GOVERNMENT COLLEGE (A) RAJAHMUNDRY

DEPARTMENT OF PHYSICS

III.BSc-Material Science. - Semester-VI,

COURSE 13: SMART MATERIALS AND STRUCTURES

Course Objective:

To introduce students to smart materials, their properties, mechanisms, and applications in modern engineering and technology, with emphasis on responsive and adaptive systems.

Learning Outcomes

1. Explain the concept and classification of smart materials.
2. Describe piezoelectric and electrostrictive materials with applications.
3. Understand the mechanism and uses of shape memory alloys and polymers.
4. Analyze the properties of magnetostrictive and chromogenic materials.
5. Identify applications of smart materials in engineering and healthcare.

Unit I: Introduction to Smart Materials (9 hrs)

Definition and concept of smart/intelligent materials, Classification: Active and passive smart materials, Basic requirements of smart structures, Examples of smart material systems

Unit II: Piezoelectric and Electrostrictive Materials (9 hrs)

Piezoelectricity: principle, direct and converse effects, Applications: sensors, actuators, energy harvesting, Electrostriction: definition and applications, Comparison between piezoelectric and electrostrictive materials

Unit III: Shape Memory Alloys and Polymers (9 hrs)

Shape memory effect and mechanism, Examples: Nitinol and Cu-based alloys, Applications in actuators, robotics, biomedical devices, Introduction to shape memory polymers and their applications

Unit IV: Magnetostrictive and Electrochromic Materials (9 hrs)

Magnetostriction: principle and applications, Electrochromic materials and devices, Applications in displays and smart windows, Other chromogenic systems: thermochromic and photochromic materials

Unit V: Applications of Smart Materials (9 hrs)

Smart sensors and actuators, Smart structures in aerospace and civil engineering, Biomedical and healthcare applications, Future prospects and challenges in smart materials research

Reference Books

1. M.V. Gandhi, B.S. Thompson, Smart Materials and Structures, Chapman & Hall.
2. Julian W. Gardner, Vijay K. Varadan, Osama O. Awadelkarim, Microsensors, MEMS and Smart Devices, Wiley.
3. J. Holnicki-Szulc, Smart Materials and Structures, Wiley.

GOVERNMENT COLLEGE (A) RAJAHMUNDRY

DEPARTMENT OF PHYSICS

III.BSc-Material Science. - Semester-VI,

COURSE 14: NON-DESTRUCTIVE TESTING (NDT)

Course Objective:

To provide knowledge of principles, techniques, applications, and limitations of various non-destructive testing methods used in materials evaluation and quality assurance.

Learning Outcomes

1. Identify appropriate NDT methods for different materials and defects.
2. Describe the working principles of LPT, MPT, RT, ECT, UT, and AET.
3. Analyze the applications and limitations of various NDT methods.
4. Evaluate safety measures in radiography and ultrasonic testing.
5. Apply NDT methods in real-world quality assurance problems.

Unit I: Visual Inspection and Liquid Penetrant Testing (9 hrs)

Introduction to NDT, scope and importance, Visual examination methods and limitations, Liquid penetrant testing – principles and procedure, Penetrant testing materials, sensitivity, applications, limitations

Unit II: Magnetic Particle Testing and Radiography (9 hrs)

Magnetic particle testing – principle and techniques, Equipment, procedure, sensitivity, applications, limitations, Radiography – basic principles, X-ray and gamma-ray radiography, film techniques, radiographic imaging, Real-time radiography and safety aspects

Unit III: Eddy Current Testing (9 hrs)

Eddy current testing – principle and instrumentation, Techniques and sensitivity, Applications and limitations, Comparison with other NDT methods

Unit IV: Ultrasonic Testing (9 hrs)

Properties of ultrasound, sound beam interaction with materials, Ultrasonic transducers and equipment, Normal beam inspection methods, Flaw characterization techniques, Immersion testing, modes of display, applications and limitations

Unit V: Acoustic Emission and Applications of NDT (9 hrs)

Acoustic emission testing – principles and techniques, Defects in materials – casting, forging, rolling, extrusion, drawing defects, Heat treatment and service defects, Selection of suitable NDT methods for different defects, Reliability and limitations of NDT methods

Reference Books

- Baldev Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-Destructive Testing, Narosa.

- Paul E. Mix, Introduction to Non-Destructive Testing, Wiley.

- American Society for Nondestructive Testing, NDT Handbook, ASNT.

GOVERNMENT COLLEGE (A) RAJAHMUNDRY
Department of Physics
III B.Sc. Materials Science – Semester VI
COURSE 15: INSTRUMENTATION

Course Objective: To familiarize students with principles, working, and applications of basic electronic instrumentation including measurement systems, sensors, transducers, and display devices for materials science applications.

Learning Outcomes

1. Understand the principles of measurement systems and their characteristics.
2. Use electrical measuring instruments for voltage, current, and resistance.
3. Operate oscilloscopes and signal analyzers for waveform observation.
4. Explain working of various transducers and sensors.
5. Operate the Optical microscope to study materials.

Unit I: Basics of Measurement Systems (9 hrs)

Generalized measurement system – input, transducer, signal conditioning, display; Static and dynamic characteristics of instruments – accuracy, precision, sensitivity, linearity, Errors in measurements and error analysis

Unit II: Electrical Measuring Instruments (9 hrs)

Moving coil and moving iron instruments – voltmeters, ammeters, Digital voltmeters and multimeters, Measurement of resistance, capacitance, inductance using bridges, True RMS meters

Unit III: Oscilloscopes and Signal Analysis (9 hrs)

Cathode ray oscilloscope (CRO) – construction, working, and applications, Dual trace and storage oscilloscopes, Signal and spectrum analyzers, Introduction to digital oscilloscopes

Unit IV: Transducers and Sensors (9 hrs)

Definition and classification of transducers, Resistive, capacitive, inductive transducers, Thermistors, RTDs, thermocouples, Strain gauges, LVDT, piezoelectric sensors, Optical and ultrasonic sensors

Unit V: Optical Instruments for Materials Science (9 hrs)

Optical Microscopy – Basic Components: eyepiece, objectives, stage, condenser, illumination system; Magnification and Resolution – concept, numerical aperture, resolving power; Types of Microscopy in Optical Range: bright field, dark field, phase contrast, polarized light microscopy; Polarizing microscope – principle and applications in materials; Fluorescence microscopy – basics and uses; Applications of optical microscopy in materials science (grain size, surface defects, inclusions, microstructure studies)

Reference Books

- H.S. Kalsi, Electronic Instrumentation, Tata McGraw-Hill.
- A.K. Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai.