Syllabus of

Bachelor of Science in Physics (BS in Physics)/ ADS in Physics (Only first four semesters)

Approved by Academic Council, **item no.17** in its **97th meeting** held on **7th July 2026** (Notification no. **68/30-AC/Acad: (26),** dated: 15-07-2026)

Revised in accordance with

- HEC revised curricula for degree programs in physics, no. HEC/CD/NCRC/PHYSICS/2025/7134 (February 11, 2025).
- Undergraduate Education Policy V 1.1 (2023), Curriculum Division HEC, Government of Pakistan

Effective from the Session Fall 2026 Onward

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BS-Physics Scheme of Studies

S.No	Domain	Number of Courses	Number of Credit Hours	Number of Credit Hours till 4th semester (for ADS in Physics)
1	General Education Courses (G)	15	34	34
2	Major Courses	28	84	33
3	Interdisciplinary Courses	06	18	06
Total		**47**	**136**	**73**

List of General Courses offered in Semester

S.No	Course Title	Credit Hours
1	Quantitative Reasoning-I	3(3-0)
2	Quantitative Reasoning-II	3(3-0)
3	Arts and Humanities (Introduction to History, Introduction to Philosophy, Introduction to Mass Communication, Introduction to Psychology)	2(2-0)
4	Natural Sciences (Chemistry or other natural science course)	3(2-1)
5	Functional English	3(3-0)
6	Expository writing	3(3-0)
7	Islamic Studies	2(2-0)
8	Ideology and Constitution of Pakistan	2(2-0)
9	Application of Information and Communication technologies (ICT)	3(2-1)
10	Entrepreneurship	2(2-0)
11	Social Sciences (Introduction to Geography, Fundamental of Disaster Management, Introduction to International Relations, Introduction to Sociology, Introduction to Political Science, Fundamentals of Economics)	2(2-0)
12	Civics and Community Engagement	2(2-0)
13	Pakistan Studies	2(2-0)
14	Understanding of Quran-I (Fehm e Quran-I)	1(0-1)
15	Understanding of Quran-II (Fehm e Quran-II)	1(0-1)
	Total	**34**

List of Major Courses Offered in semester
Note: Minimum requirement 84 credit hours

S.No	Course Code	Course Title	Credit Hours
1.	PHY-501	Introductory Mechanics	3(2-1)
2.	PHY-509	Waves and Optics	3(2-1)
3.	MATH-501	Calculus-I	3 (3-0)
4.	MATH-502	Calculus-II	3 (3-0)
5.	PHY-503	Heat and thermodynamics	3(2-1)
6.	PHY-504	Electricity and magnetism	3(2-1)
7.	PHY-505	Modern Physics	3(2-1)
8.	MATH-521	Vector Calculus	3(3-0)

9.	MATH-509	Differential Equation	3 (3-0)
10.	PHY-508	Electronics –I	3(2-1)
11.	PHY-510	Classical Mechanics	3(3-0)
12.	PHY-602	Electronics- II	3(2-1)
13.	PHY-641	Condensed Matter Physics-I	3(3-0)
14.	PHY-604	Electromagnetic Theory	3(3-0)
15.	PHY-605	Mathematical Method of Physics -I	3(3-0)
16.	PHY-639	Statistical Mechanics	3(3-0)
17.	PHY-640	Electrodynamics and Special Relativity	3(3-0)
18.	PHY-610	Mathematical Method of Physics -II	3(3-0)
19.	PHY-611	Atomic and molecular Physics	3(3-0)
20.	PHY-612	Quantum Mechanics-I	3(3-0)
21.	PHY-613	Field Experience / Internship	3(0-3)
22.	PHY-614	Quantum Mechanics- II	3(3-0)
23.	PHY-615	Nuclear Physics	3(2-1)
24.	PHY-616	Capstone Project	3(3-0)
25.	PHY-6xx	Elective-I, Elective-II, Elective-III , Elective-IV	12(12-0)

List of Interdisciplinary Courses in semester
Note: Minimum 18 Credit Hours (6 cources)

S.No	Course Code	Course title	Credit Hours
1	EP- 500	Environmental Physics	3 (3-0)
2	MATH-504	Linear Algebra	3 (3-0)
3	PHY-638	Medical Physics	3 (3-0)
4	PHY-617	Computational Physics	3 (3-0)
5	PHY-637	Scientific Inquiry and Research Methods	3 (3-0)
6	PHY-642	Artificial Intelligence in Physics	3 (3-0)

Field experiences /internship (PHY-613): 03 credit hours.
Capstone Project (PHY-616): 03 credit hours.

Bachelor of Science in Physics Syllabus

Programme: Bachelor of Science in Physics (BS in Physics)
Duration: 4 years
Number of semesters: 8
Number of weeks per semester: 16-18 (2 weeks for examinations)
Total number of credit hours: 136
Quit Option: After 4 semesters if any student wants to quit, he/she will be awarded ADS (in Physics).
Number of credit hours per semester: 15-19
Eligibility Criteria for Admission: FSc /A-Level Cambridge (with Physics or Mathematics) / Three-year polytechnic degree

Semester 1

Course Code	Course Title	Course Type	Credit Hours
PHY-501	Introductory Mechanics	Major	3(2 – 1)
MATH-501	Calculus-I	Major	3 (3 – 0)
CS-501	Application of Information and Communication technologies (ICT)	General course	3 (2 – 1)
ENG-501	Functional English	General course	3 (3 – 0)
QR-501	Quantitative Reasoning-I	General course	3 (3 – 0)
ISL-501	Islamic Studies / Ethics	General course	2 (2 – 0)
IS-524	Understanding of Quran-I (Fehm e Quran-I)	General course	1 (0 – 1)
Total			**18**

Semester 2

Course Code	Course Title	Course Type	Credit Hours
PHY-509	Waves and Optics	Major	3 (2 – 1)
PHY-503	Heat and Thermodynamics	Major	3 (2 – 1)
MATH-502	Calculus-II	Major	3 (3 – 0)
EP- 500	Environmental Physics	Interdisciplinary	3 (3 – 0)
QR-502	Quantitative Reasoning-II	General course	3 (3 – 0)
ENG-502	Expository writing	General course	3 (3 – 0)
IS-534	Understanding of Quran-II (Fehm e Quran-II)	General course	1 (0 – 1)
Total			**19**

Semester 3

Course Code	Course Title	Course Type	Credit Hours
PHY-504	Electricity & Magnetism	Major	3 (2 – 1)
PHY-505	Modern Physics	Major	3 (2 – 1)
MATH-521	Vector Calculus	Major	3 (3 – 0)
MATH-504	Linear Algebra	Interdisciplinary	3 (3 – 0)
GC-5xx	Arts and Humanities Arts and Humanities (Introduction to History/ Philosophy /Mass Communication / Psychology (PSY-501))	General Course	2 (2 – 0)
SOC-502	Civics and Community Engagement	General course	2 (2 - 0)
PS-526	Ideology and Constitution of Pakistan	General course	2 (2 – 0)
Total			**18**

Semester 4

Course Code	Course Title	Course Type	Credit Hours
PHY-508	Electronics-I	Major	3 (2 – 1)
PHY-510	Classical Mechanics	Major	3 (2 – 1)
MATH-509	Differential Equations	Major	3 (3 – 0)
CHEM-500	Chemistry (Natural Sciences)	General course	3 (2 – 1)
ENT-508	Entrepreneurship	General course	2 (2 – 0)
PS-501	Pakistan Studies	General course	2 (2 – 0)
GC-5XX	Social Sciences ((Introduction to Geography, Fundamental of Disaster Management, Introduction to International Relations, Introduction to Sociology, Introduction to Political Science, Fundamentals of Economics)	General course	2 (2 - 0)
Total			**18**

Exit Option: Associate degree (ADS in Physics – Cut-Off Degree)

In accordance with the HEC Undergraduate Education Policy (Version 1.1), students enrolled in the BS (Physics) program shall be eligible to exit the program with an associate degree (ADS in Physics – Cut-Off Degree), subject to fulfillment of the following requirements:

Eligibility Criteria

A) The student must have successfully completed 73 credit hours, including 34 credit hours of General Education courses, within a minimum of four (04) semesters of the undergraduate program.

B) The student must have maintained a minimum cumulative grade point average (CGPA) of 2.00 on a 4.00 scale.

C) The title of the associate degree shall remain the same as the original field of enrolment, i.e., Physics.

Semester 5

Course Code	Course Title	Course Type	Credit Hours
PHY-602	Electronics-II	Major	3 (2 – 1)
PHY-604	Electromagnetic Theory	Major	3 (3 – 0)
PHY-605	Mathematical Methods of Physics-I	Major	3 (3 – 0)
PHY-637	Scientific Inquiry and Research Methods	Interdisciplinary	3 (3 – 0)
PHY-638	Medical Physics	Interdisciplinary	3 (3 – 0)
PHY-617	Computational Physics	Interdisciplinary	3 (2 – 1)
Total			**18**

Semester 6

Course Code	Course Title	Course Type	Credit Hours
PHY-639	Statistical Mechanics	Major	3 (3 – 0)
PHY-610	Mathematical Methods of Physics-II	Major	3 (3 – 0)
PHY-612	Quantum Mechanics-I	Major	3 (3 – 0)
PHY-640	Electrodynamics and Special Relativity	Major	3 (3 – 0)
PHY-641	Condensed Matter Physics-I	Major	3 (3 – 0)
Total			**15**

Semester 7

Course Code	Course Title	Course Type	Credit Hours
PHY-611	Atomic and Molecular Physics	Major	3 (2 – 1)
PHY-614	Quantum Mechanics-II	Major	3 (3 – 0)
PHY-6xx	Elective Course- I	Major	3 (3 – 0)
PHY-6xx	Elective Course- II	Major	3 (3 – 0)
PHY-613	Field Experience / Internship	Major	3 (0 - 3)
Total			**15**

Semester 8

Course Code	Course Title	Course Type	Credit Hours
PHY- 615	Nuclear Physics	Major	3 (2 – 1)
PHY-642	Artificial Intelligence in Physics	Major	3 (2 – 1)
PHY-6xx	Elective Course-III	Major	3 (3 – 0)
PHY-6xx	Elective Course-IV	Major	3 (3 – 0)
PHY-616	**Capstone Project:** The research work will be conducted in 8th semester. In the final defense of project, a prototype will be shown to the external examiner and a project report will be submitted.	Major	3 (0 - 3)
Total			**15**

Optional Subjects (Elective Courses) in 7th and 8th Semesters

PHY-618	Mechatronics	3 (2 – 1)
PHY-619	Nanoscience and Nanotechnology	3 (2 – 1)
PHY-620	Communication System	3 (2 – 1)
PHY-621	Condensed Matter Physics-II	3 (3 – 0)
PHY-622	Plasma Physics	3 (3 – 0)
PHY-623	Quantum Field Theory	3 (3 – 0)

PHY-624	Fluid Dynamics	3 (3 – 0)
PHY-625	Introduction to Materials Science	3 (3 – 0)
PHY-626	Particle Physics	3 (3 – 0)
PHY-627	Introduction to Renewable Energy	3 (3 – 0)
PHY-628	Wind Energy	3 (3 – 0)
PHY-629	Hydro Power Systems	3 (3 – 0)
PHY-630	Tidal and Geothermal Energy	3 (3 – 0)
PHY-631	Solar Energy	3 (3 – 0)
PHY-632	Hydrogen and Fuel Cells	3 (3 – 0)
PHY-633	Energy Storage	3 (3 – 0)
PHY-634	Photovoltaic	3 (3 – 0)
PHY-635	Microbial Bioenergy and Biofuel	3 (3 – 0)
PHY-636	CAD and 3D Printing	3 (1 – 2)
PHY-637	Cosmology	3 (3 – 0)
PHY-638	Introduction to Quantum Computing	

Total Credit Hours: 136

Two-Two optional/Elective subjects of 03 credit hours each will be offered in 7th and 8th semesters. Internship will be offered to students during 7th semester or in sessional break. Capstone Project will be allocated in the 8th semester and the final defense will be held at the end of 8th semester.

PHY-501 INTRODUCTORY MECHANICS Credit Hours: 3(2-1)

Major Course

Objectives:

The main objective of this course is to understand the different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Course Learning Outcomes

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

- 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.

Contents:

Basic Concepts: Scalars and Vectors, Multiplication of Vectors: Dot and Cross Products. Vector triple product, scalar triple product, Del Operator, Divergence theorem, stokes theorem, Coordinate systems: Cartesian system, spherical, cylindrical system of coordinates.

Motion in One, Two and Three Dimensions: Position & Displacement, Velocity and Acceleration, Motion under Constant Acceleration, Projectile Motion, Uniform Circular Motion, Relative Velocity and Acceleration in One and Two Dimensions, Inertial and Non-Inertial Reference Frames.

Newton's Laws: Newton's Laws of Motion and their Applications involving some particular forces including Weight, Normal Force, Tension, Friction, and Centripetal Force, Newton's Law of Gravitation, Gravitational Potential Energy, Escape Velocity, Kepler's Laws, Satellite Orbits & Energy.

Work and Kinetic Energy: Work done by Constant and Variable Forces: Gravitational and Spring Forces, Power, Conservative and Non-conservative Forces, Work and Potential Energy, Isolated Systems and Conservation of Mechanical Energy, Work Done by External Forces including Friction and Conservation of Energy.

System of Particles: Motion of a System of Particles and Extended Rigid Bodies, Center of Mass and Newton's Laws for a System of Particles, Linear Momentum, Impulse, Momentum & Kinetic Energy in One- and Two-Dimensional Elastic and Inelastic Collisions.

Rotational Motion: Rotation about a Fixed Axis, Angular Position, Angular Displacement, Angular Velocity and Angular Acceleration, Rotation under Constant Angular Acceleration, relationship between Linear and Angular Variables, Rotational Inertia, Parallel-axis Theorem, Torque and Newton's Law for Rotation, Work and Rotational Kinetic Energy, Power, Rolling Motion, Angular Momentum for a single Particle and a System of Particles, Conservation of Angular Momentum, Precession of a Gyroscope, Static Equilibrium involving Forces and Torques, Determination of moment of inertia of various shapes i.e. for disc, bar and solid sphere.

Angular Momentum: Angular Velocity, Conservation of angular momentum, effects of Torque and its relation with angular momentum.

Simple Harmonic Motion (SHM): Amplitude, Phase, Angular Frequency,
Velocity and Acceleration in SHM, Linear and Angular Simple Harmonic Oscillators, Energy in SHM, Simple Pendulum, Physical Pendulum, SHM and Uniform Circular Motion, Damped Harmonic Oscillator.

Experiments:

1. To determine the value of "g" by simple pendulum.
2. To determine the value of "g" by compound pendulum/ Kater's Pendulum.
3. To study the damping features of an oscillating system using simple pendulum of variable mass.
4. To study the dependence of Centripetal force on mass, radius, and angular velocity of a body in circular motion.

5. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc
6. Determination of the Modulus of rigidity of a wire by Static Method.
7. Determination of the modulus of rigidity of a wire by Maxwell's needle (dynamic method).
8. Determination of the modulus of rigidity of a wire by oscillating rod (Dynamic method).
9. Determination of the surface tension of water by capillary tube method.
10. Determination of Co-efficient of Viscosity of water by flow method.
11. Determination of the Co-efficient of viscosity of a liquid by Stoke's Law.
12. To study the dependence of centripetal force on mass, radius, and angular velocity of a body in circular motion.
13. Study of the Damping features of an oscillating system using Simple Pendulum of variable mass.
14. Determination of the moment of inertia of a solid/hollow cylinder and sphere.
15. To study the Conservation of Energy (Hooke's Law Apparatus)
16. Determination of the vertical distance between two points using a sextant.

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010.
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed. 2008.

MATH-501 CALCULUS- I Credit Hours: 3 (3-0)

Major Course

Prerequisites: Knowledge of Intermediate Calculus

Course Learning Outcomes

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

- 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 compute areas and volumes.

Contents:

Foundational Algebra & Functions:

Equations and inequalities: Solving linear and quadratic equations, linear inequalities. **Polynomials:** Division of polynomials, synthetic division, roots of a polynomial, rational roots, Vieta's Relations, and Descartes' rule of signs.

Functions and Graphs: Domain and range. Examples and evaluation of polynomial, rational, piecewise-defined, and absolute value functions. Operations with Functions: Sum, product, quotient, and composition.

Graphs of Functions: Linear, quadratic, and piecewise-defined functions.

Lines and Systems: Equation of a straight line, slope/intercept, parallel and perpendicular lines. Systems of linear equations and non-linear systems (with at least one quadratic equation).

Limits and Continuity: Concept of a limit and the graphical approach. Properties and theorems of limits. Limits of polynomials, rational, and transcendental functions. Limits at infinity, infinite limits, and one-sided limits. Continuity of functions.

Derivatives: Definition of a derivative. Techniques of differentiation: Derivatives of polynomials, rational, exponential, logarithmic, and trigonometric functions. The Chain Rule and Implicit differentiation. Higher derivatives and Leibnitz's theorem. Inverse functions and their derivatives.
Rates of Change: Rates of change in natural and social sciences, and related rates.
Applications of Derivatives: Determining increasing and decreasing functions. Relative extrema and optimization problems. Curve sketching and Mean Value Theorems. Indeterminate forms and L'Hôpital's Rule.
Foundations of Integration: Antiderivatives and indefinite integrals. Riemann sums and the definition of a definite integral. Properties of the integral. The Fundamental Theorem of Calculus. The Substitution Rule (Integration by *u*-substitution). Finding the area between curves. Computing volumes of solids of revolution (using the disk, washer, or cylindrical shell methods).
Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th Edition, JohnWiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002

CS-501 APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)
General Education Course **Credit Hours: 3 (2 – 1)**

Objective:
This course is designed to provide students with an exploration of the practical applications of Information and Communication Technologies (ICT) and software tools in various domains. Students will gain hands-on experience with a range of software applications, learning how to leverage ICT to solve daily life problems, enhance productivity and innovate in different fields. Through individual and interactive exercises and discussions, students will develop proficiency in utilizing software for communication, creativity, and more.
Contents:
1. Introduction to Information and Communication Technologies:

- Components of Information and Communication Technologies (basics of hardware, software, ICT platforms, networks, local and cloud data storage etc.)
- Scope of Information and Communication Technologies (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.).
- Emerging technologies and future trends.

2. Basic ICT Productivity Tools:

- Effective use of popular search engines (e.g., Google, Bing, etc.) to explore World Wide Web.
- Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.).
- Microsoft Office Suites (Word, Excel, PowerPoint).
- Google Workspace (Google Docs, Sheets, Slides).
- Dropbox (Cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft Office integration).
- Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas).
- Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.).
- Social media applications (LinkedIn, Facebook, Instagram, etc.).

3. ICT in Education:

- Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.).

- Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.).
- Interactive multimedia and virtual classrooms.

4. ICT in Health and Well-being:

- Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkoopor, etc.).
- Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).

5. ICT in Personal Finance and Shopping:

- Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax,
- ILINK and MNET, Keenu Wallet, etc.).
- E-commerce platforms (Daraz.pk, Telemart, Shophive, etc.)

6. Digital Citizenship and Online Etiquette:

- Digital identity and online reputation.
- Netiquette and respectful online communication.
- Cyberbullying and online harassment.

7. Ethical Considerations in Use of ICT Platforms and Tools:

- Intellectual property and copyright issues.
- Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources.
- Content accuracy and integrity (ensuring that the content shared through ICT platforms is free from misinformation, fake news, and manipulation).

Practical Requirements

As part of the overall learning requirements, the course will include:

1. Guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as word processing software (e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools. Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets etc.
2. Assigning of tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems. Students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive).
3. The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.

Recommended Books:

1. "Discovering Computers" by Vermaat, Shaffer, and Freund.
2. "GO! with Microsoft Office" Series by Gaskin, Vargas, and McLellan.
3. "Exploring Microsoft Office" Series by Grauer and Poatsy.
4. "Computing Essentials" by Morley and Parker.
5. "Technology in Action" by Evans, Martin, and Poatsy

ENG-501 English I- FUNCTIONAL ENGLISH Credit Hours: 3(3-0)

General Education Course

Objectives:

This course is designed to equip 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.

Contents:

1. Foundations of Functional English:

- Vocabulary building (contextual usage, synonyms, antonyms and idiomatic expressions)
- Communicative grammar (subject-verb-agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.)
- Word formation (affixation, compounding, clipping, back formation, etc.)
- Sentence structure (simple, compound, complex and compound-complex)
- Sound production and pronunciation

2. Comprehension and Analysis:

- Understanding purpose, audience and context
- Contextual interpretation (tones, biases, stereotypes, assumptions, inferences, etc.)
- Reading strategies (skimming, scanning, SQ4R, critical reading, etc.)
- Active listening (overcoming listening barriers, focused listening, etc.)

3. Effective Communication:

- Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.)
- Structuring documents (introduction, body, conclusion and formatting)
- Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.)
- Public speaking (overcoming stage fright, voice modulation and body language)
- Presentation skills (organization content, visual aids and engaging the audience)
- Informal communication (small talk, networking and conversational skills)
- Professional writing (business e-mails, memos, reports, formal letters, etc.)

Suggested Practical Activities (Optional)

As part of the overall learning requirements, students will also be exposed to relevant simulations, role- plays and real-life scenarios and will be required to apply skills acquired throughout the course in the form of a final project.

Recommended Books:

1. "Understanding and Using English Grammar" by Betty Schrampfer Azar.
2. "English Grammar in Use" by Raymond Murphy.
3. "The Blue Book of Grammar and Punctuation" by Jane Straus.
4. "English for Specific Purposes: A Learning-Centered Approach" by Tom Hutchinson and Alan Waters.
5. "Cambridge English for Job-hunting" by Colm Downes.

QR-501 QUANTITATIVE REASONING-I Credit Hours: 3 (3 – 0)

General Course

Objective:

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 and statistics and 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.

Contents:

1. 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.

2. Fundamental Mathematical Concepts

- Basics of geometry (lines, angles, circles, polygons etc.);
- Sets and their operations;
- 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.

3. Fundamental Statistical Concepts

- Population and sample;
- Measures of central tendency, dispersion and data interpretation;
- Rules of counting (multiplicative, permutation and combination);
- Basic probability theory;
- Introduction to random variables and their probability distributions,
- Quantitative reasoning exercises using fundamental statistical concepts.

Recommended Books:

1. "Quantitative Reasoning: Tools for Today's Informed Citizen" by Bernard L., Madison, Lynn and Arthur Steen.
2. "Quantitative Reasoning for the Information Age" by Bernard L. Madison and David M. Bressoud.
3. "Fundamentals of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking in Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis" by Ethan Bueno de Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
8. "Statistics for Technology: A Course in Applied Statistics" by Chatfield, C.
9. "Statistics: Unlocking the Power of Data" by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

ISL-501 ISLAMIC STUDIES Credit Hours: 2(2-0)

General Education Course

Pre-Requisite: Nil

Objective:

This course is designed to provide students with a comprehensive overview of the fundamental aspects of Islam, its beliefs, practices, history and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course, students will have an enhanced understanding of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's historical and contemporary role, fostering empathy, respect, and informed dialogue.

Contents:

1. Introduction to Islam:

- Definition of Islam and its core beliefs.
- The Holy Quran (introduction, revelation and compilation).
- Hadith and Sunnah (compilation, classification, and significance)
- Key theological concepts and themes (Tawhid, Prophethood, Akhirah etc.)

2. Sirah of the Holy Prophet (Peace Be Upon Him) as Uswa-i-Hasana:

- Life and legacy of the Holy Prophet PBUH.
- Diverse roles of the Holy Prophet PBUH (as an individual, educator, peace maker, leader etc.).

3. Islamic History and Civilization:

- World before Islam.
- The Rashidun Caliphate and expansion of Islamic rule.
- Contribution of Muslim scientists and philosophers in shaping world civilization.

4. Islamic Jurisprudence (Fiqh):

- Fundamental sources of Islamic jurisprudence.
- Pillars of Islam and their significance.
- Major schools of Islamic jurisprudence.
- Significance and principles of Ijtihad.

5. Family and Society in Islam:

- Status and rights of women in Islamic teachings.
- Marriage, family, and gender roles in Muslim society.
- Family structure and values in Muslim society.

6. Islam and the Modern World:

- Relevance of Islam in the modern world (globalization, challenges and prospects).
- Islamophobia, interfaith dialogue, and multiculturalism.
- Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books:

1. "The Five Pillars of Islam: A Journey Through the Divine Acts of Worship" by Muhammad Mustafa Al-Azami.
2. "The Five Pillars of Islam: A Framework for Islamic Values and Character Building" by Musharraf Hussain.
3. "Towards Understanding Islam" by Abul A'la Mawdudi.
4. "Islami Nazria e Hayat" by Khurshid Ahmad.
5. "An Introduction to Islamic Theology" by John Renard.
6. "Islamic Civilization Foundations Belief & Principles" by Abul A' la Mawdudi.
7. "Women and Social Justice: An Islamic Paradigm" by Dr. Anis Ahmad.
8. "Islam: Its Meaning and Message" by Khurshid Ahmad.

Note: This course is compulsory for Muslim and optional for non-Muslim undergraduate students. Non-Muslim students can opt for any course of at least the same or more credits in subjects such as religious studies, ethics, theology, comparative religion, Christian ethics, etc.

ISL-501 ETHICS for NON-MUSLIMS Credit Hours: 2(2-0)

نصاب بی اے اخلاقیات (غیر مسلم طلباء کے لیے)

Syllabus of B.A.Ethics (for Non Muslim)

۱۔ تعریف اخلاق، علم الاخلاق کا دیگر علوم سے تعلق (علم الاخلاق اور نفسیات، علم الاخلاق اور عمرانیات، علم الاخلاق اور سیاسیات، علم الاخلاق اور قانون)

۲۔ اسلام کا فلسفہ اخلاق، اسلام میں اخلاق کی اہمیت، فضائل اخلاق (صدق، سخاوت، عفت و پاکیزگی، دیانتداری، عدل وانصاف، عہد کی پابندی، احسان، عفو و درگذر) اخلاق ذمیمہ (جھوٹ، خیانت، غداری، چوری، رشوت، ظلم)

۳۔ عیسائیت کی اخلاقی تعلیمات، عقیدہ تثلیث، عقیدہ کفارہ، عقیدہ مصلوبیت، بپتسمہ، عشائے ربانی، اناجیل اربعہ۔

۴۔ ہندومت کی اخلاقی تعلیمات، عقیدہ تری مورتی، آواگون، ذات پات، مذہبی کتب۔

۵۔ گرونانک کی حیات وخدمات، تصور معبود، تصور عبادت، خالصہ اور ان کے پانچ کاف۔

۶۔ گوتم بدھ کے حالات زندگی اور اخلاقی تعلیمات، بھکشو بننے کے لیے شرائط، ہشت پہلو۔

مطالعاتی کتب:

(۱) سید سلیمان ندوی	سیرت النبی (جلد ششم)	(۲) حفظ الرحمٰن سیوہاروی	اخلاق وفلسفہ اخلاق
(۳) سی اے قادر	اخلاقیات	(۴) خورشید احمد	اسلامی نظریہ حیات
(۵) مولنا مودودی	اسلام کا اخلاقی نقطہ نظر	(۶) امام غزالی	اسلامی آداب واخلاق
(۷) عبدالعلی اچکزئی	روضۃ الاسلام	(۸) عبدالعلی اچکزئی	روضہ علوم اسلامیہ (۲)
(۹) عبدالرشید	ادیان ومذاہب کا تقابلی مطالعہ	(۱۰) غلام رسول چیمہ	مذاہب عالم کا تقابلی مطالعہ

IS-524 UNDERSTANDING OF QURAN-I (FEHM- E- QURAN-I) Credit Hours: 1(0-1)
General Education Course

Pre-Requisite: Nil

Objective:

The course aims to develop students' ability to understand the basic vocabulary, phrases, and sentence structures of the Holy Quran, beginning with nominal sentences and progressing to present-tense verbal constructions. It seeks to establish a strong foundation in Quranic Arabic by introducing essential vocabulary, particles, compounds, pronouns, plural forms, and common linguistic patterns found in the Quran.

Course Learning Outcomes:

By the end of this course, students will be able 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 plural 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.

Provision of material, content and books:

1 Paper book: All volumes are available in printed book form.
2 Tutorial videos: Teaching video of each lesson available on YouTube.
3 Confirmation Videos: A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
4 A flipbook: A flipbook edition is also accessible.
5 Helping material: Helping material for the teachers like quizzes, question papers and images is available on website.

PHY-509 WAVES AND OPTICS Credit Hours: 3(2-1)
Major course

Pre-requisites: Mechanics, Calculus II

Objectives:

To develop a unified mathematical theory of oscillations and waves in physical systems.

Course Learning Outcomes:

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

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

Contents:

Oscillatory Motion and Foundations of Waves: Periodic motion: displacement, velocity, acceleration, amplitude, phase and energy. Simple harmonic motion: mass-spring system and simple pendulum as introductory models. Damped and forced oscillations: resonance, quality factor and physical examples. Transition from oscillation to wave propagation: wave parameters and notation.

Mechanical Waves and Wave Equation: Propagation of a disturbance: transverse and longitudinal waves. Sinusoidal traveling waves: wavelength, frequency, angular frequency, wave number, phase constant and wave speed. One-dimensional wave equation on a stretched string: boundary conditions. Energy and power carried by mechanical waves: reflection and transmission at boundaries. Wave impedance, phase velocity, group velocity, wave packets and introductory dispersion.

Sound Waves, Superposition and Standing Waves: Pressure variations in sound waves: speed of sound in gases and other media. Intensity, sound level and decibel scale; periodic sound waves. Principle of superposition: constructive and destructive interference; beats. Standing waves on strings: normal modes and harmonics. Standing waves in air columns, rods and membranes: resonance and musical acoustics. Doppler effect for sound: brief comparison with light at conceptual level.

Electromagnetic Waves and Nature of Light: Light as an electromagnetic wave: transverse nature of electromagnetic waves. Speed of light, electromagnetic spectrum and intensity of light. Wavefronts, rays and Huygens principle. Propagation of electromagnetic waves in vacuum and dielectric media: refractive index and optical path. Reflection, refraction, transmission, absorption and dispersion in media. Introductory idea of polarization as a property of electromagnetic waves.

Geometrical Optics and Image Formation: Ray approximation: Fermat principle and laws of reflection and refraction. Total internal reflection and applications including prisms and optical fibers. Images formed by plane and spherical mirrors; mirror equation and magnification. Refraction at plane and spherical surfaces: thin lenses, lens equation and lens combinations. Lens aberrations: spherical and chromatic aberration at introductory level. Camera, eye, simple magnifier, compound microscope and telescope.

Interference and Coherence: Coherence, optical path difference, phase difference and intensity superposition. Young double-slit experiment: fringe spacing and intensity distribution. Change of phase due to reflection: interference in thin films. Newton rings and anti-reflection coatings. Michelson interferometer and introductory applications in precision measurement.

Diffraction and Resolving Power: Huygens-Fresnel principle: Fresnel and Fraunhofer diffraction at introductory level. Single-slit diffraction; double-slit interference with diffraction envelope. Circular aperture, Rayleigh criterion and resolving power. Multiple slits and diffraction grating: grating equation. Diffraction of X-rays by crystals and Bragg law.

Polarization and Modern Optical Systems: Linear, circular and elliptical polarization: unpolarized and partially polarized light. Malus law, Brewster law and polarization by reflection. Birefringence, wave plates, polarizers, analyzers and optical activity. Introductory modern applications: lasers, optical fibers, imaging sensors, spectroscopy and optical communication.

Lab work Waves and Optics (1 credit hour)

1. Verify simple harmonic motion using a mass-spring system or pendulum.
2. Study damped oscillations
3. To study Doppler Effect, Wave propagation, Reflection, Refraction and Diffraction using ripple tank system
4. Study standing waves on a string using a sonometer or Melde experiment.
5. Determine the speed of sound using resonance tube
6. Observe beats using tuning forks or signal-generator/audio-app simulation.
7. Verify mirror/lens formula and determine focal length.
8. Measure refractive index and dispersive power of a prism using a spectrometer.
9. Study total internal reflection and numerical aperture of an optical fiber.
10. To determine wavelength of Na light by using diffraction grating.
11. Determination of wavelength of sodium light by Fresnel's bi-prism.
12. Determine wavelength of light using Young’s double-slit or Newton rings.

13. Study single-slit diffraction and diffraction grating using a laser.
14. Determination of the wavelength of the light using Michelson-interferometer.

Recommended Books

1. Serway, R. A. and Jewett, J. W. Physics for Scientists and Engineers with Modern Physics, Cengage Learning, latest available edition.
2. Young, H. D. and Freedman, R. A. University Physics with Modern Physics, Pearson, latest available edition.
3. Serway, R. A., Vuille, C. and Faughn, J. S. College Physics, Cengage Learning, latest available edition.
4. Hecht, E. Optics, Pearson, 5th edition or latest available edition.
5. Pedrotti, F. L., Pedrotti, L. S. and Pedrotti, L. M. Introduction to Optics, Cambridge University Press, 3rd edition.
6. Ghatak, A. Optics, McGraw Hill, latest available edition.
7. Fowles, G. R. Introduction to Modern Optics, Dover, 2nd edition.
8. Jenkins, F. A. and White, H. E. Fundamentals of Optics, McGraw Hill, 4th edition.
9. Crawford, F. S. Waves: Berkeley Physics Course, Vol. 3, McGraw Hill.

PHY-503 HEAT AND THERMODYNAMICS Credit Hours: 3 (2-1)

Major course

Pre-requisites: Mechanics

Objectives: To understand the fundamentals of heat and thermodynamics.

Course Learning Outcomes

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

- 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.

Contents:

Basic Concepts and Definitions in Thermodynamics: Thermodynamic system, Surrounding and Boundaries. Types of system. Macroscopic and microscopic description of system. Properties and state of the substance: Extensive and Intensive properties, Equilibrium, Mechanical and Thermal Equilibrium. Processes and Cycles: Isothermal, Isobaric and Isochoric. Zeroth Law of Thermodynamics, Consequence of Zeroth law of Thermodynamics. The state of the system at Equilibrium.

Heat and Temperature: Temperature, Kinetic theory of ideal gas, Work done on an ideal gas, Review of previous concepts.

Internal energy of an ideal gas: Equipartition of Energy, Intermolecular forces, Qualitative discussion, The Virial expansion, The Van der Waals equation of state.

Law of Thermodynamics: First law of thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion. Reversible and irreversible processes. Second law of thermodynamics, Carnot theorem and Carnot engine. Heat engine, Refrigerators. Calculation of efficiency of heat engines. Thermodynamic temperature scale: Absolute zero, Entropy, Entropy in reversible process, Entropy in irreversible process. Entropy and Second law of thermodynamics, Entropy and Probability. Thermodynamic functions (Internal energy, Enthalpy, Gibb's functions, Entropy, Helmholtz functions), Maxwell's relations, TdS equations, Energy equations and their applications. Low Temperature Physics, Joule-Thomson effect and its equations. Thermoelectricity: Thermocouple, Seabeck's effect, Peltier's effect.

Experiments:

1. Measurement of the Thermal E.M.F. of a thermocouple as a function of temperature between its Hot and Cold junctions.

2. Determination of the temperature co-efficient of resistance of a wire.
3. Determination of the Mechanical Equivalent of Heat by J Callendar and Barne's constant flow apparatus with heat loss compensation.
4. Determination of Stefan's constant.
5. Calibration of a thermocouple by potentiometer.

Recommended Books:

1. D. Halliday, R. Resnick and K. Krane, "Physics", John Wiley, 5th ed.2002.
2. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley, 9th ed. 2010.
3. M. W. Zemansky, "Heat and Thermodynamics", Mc Graw Hill, 7th ed.1997.
4. M. Sprackling, "Thermal Physics" McMillan 1991.
5. B. N. Roy, "Principle of Modern Thermodynamics", Institute of Physics,London 1995.

MATH-502 CALCULUS –II Credit Hours: 3(3-0)

Major course

Prerequisites: Calculus I

Objectives: This is second course of Calculus. As continuation of Calculus I, it focuses on techniques of integration and applications of integrals. The course also aims at introducing the students to infinite series, parametric curves and polar coordinates.

Course Learning Outcomes

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

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

Contents:

Techniques of integration Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions. Integration by parts, substitution and partial fractions. Approximate integration. Improper integrals.

Applications of integrals: Area under and between curves, Area between lines, area between the line and curve, average value. Volumes. Arc length. Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology.

Power series. Convergence of power series. Representation of functions as power series. Differentiation and integration of power series. Taylor and McLaurin series. Approximations by Taylor polynomials.

Conic section: parameterized curves and polar coordinates: Curves defined by parametric equations. Calculus with parametric curves: tangents, areas, arc length. Polar coordinates. Polar curves, tangents to polar curves. Areas and arc length in polar coordinates.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison WesleyPublishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, Calculus, Schaum's outlines series, 4th Edition, 1999
5. C.H. Edward and E.D Penney, Calculus and Analytics Geometry, Prentice Hall, Inc. 1988

EP-500 ENVIROMENTAL PHYSICS Credit Hours: 3 (2-1)

Interdisciplinary Course

Objectives:

To become familiar with the essentials of environment and Global climate. To learn to use spectroscopy for environments.

Course Learning Outcomes:

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

- 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.

Contents:

1. Introduction to Environmental Physics

Scope and importance of environmental physics; Components of Environment (hydrosphere, biosphere, lithosphere); Environment Scale (local, regional and global); Matter and energy in environment; Population growth and resource use; Environmental challenges and sustainable development.

2. Fundamentals of Environmental Radiations

Electromagnetic spectrum; Blackbody radiation; Solar radiation and solar constant; Interaction of radiations with environment (absorption, reflection and transmission); Solar ultraviolet radiation; Interaction of radiations with biological systems; Photosynthetically active radiations; Radiation hazards; Ozone layer; Ozone depletion and consequences.

3. Earth's energy balance, thermodynamics and greenhouse effect

Incoming solar radiations; Outgoing earth's radiations; Planetary Albedo; Radiation balance; Earth's energy budget; Temperature and heat; Heat transfer: conduction, convection and radiation; Natural greenhouse effect; Greenhouse gases; Radiative forcing.

4. Atmosphere and climate Physics

Composition of atmosphere; Layers of atmosphere; Vertical profiles of temperature pressure and density; Lateral movements in atmosphere; Concepts of weather and climate; Natural climate variability; Climate modeling.

5. Topo climate and micro climate

Concepts of topo and micro climates; Effects of surface features on local climate; Effects of vegetation and water bodies on local climate; Topography: mountain and valley climate, coastal and desert climate.

6. Climatology and measurements of climatic factors

Introduction to environmental measurements; Observation and recording techniques; Measurements of temperature, humidity, wind (speed and direction), atmospheric pressure, and precipitation; Radiation balance; Measurement of solar radiation; Measurement of radiation balance (Net radiation); Automatic weather station.

Experiments:

1. Measurement of Electrical conductivity of Extract from Soil Saturated paste by use of digital conductivity Meter.
2. Measurmrnt of Viscosity of water.
3. Measurement of intensity of Noise by sound level meter.
4. Measurement of Air pollution by stochastic modeling techniques.
5. Measurement of conductivity of water.
6. Measurement of Relative humidity by using Dry and Wet bulb thermometers.
7. Measurement of total dissolved solids in water sample.
8. Preparation of EIA reports for Environmental protection.

9. Measurement of Different Atmospheric parameters. .

Recommended Books:

1. Hughes, P. and Mason, N.J., *Introduction to Environmental Physics: Planet Earth, Life and Climate*, Taylor & Francis.
2. Boeker, E. and van Grondelle, R., *Environmental Physics*, John Wiley & Sons.
3. Guyot, G., *Physics of the Environment and Climate*, John Wiley & Sons.
4. Brock, F.V. and Richardson, S.J., *Meteorological Measurement Systems*, Oxford University Press.

QR-502 QUANTITATIVE REASONING-II Credit Hours: 3 (3 – 0)

General course

Objectives:

Quantitative Reasoning (II) is a sequential undergraduate course that focuses on logical reasoning supported with mathematical and statistical concepts and modeling / analysis techniques to equip students with analytical skills and critical thinking abilities necessary to navigate the complexities of the modern world. The course is designed to familiarize students with the quantitative concepts and techniques required to interpret and analyze numerical data and to inculcate an ability in students the logical reasoning to construct and evaluate arguments, identify fallacies, and think systematically. Keeping the pre-requisite course of Quantitative Reasoning (1) as its base, this course will enable students further their quantitative, logical and critical reasoning abilities to complement their specific major/field of study.

Contents:

1. 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.

2. 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

3. Statistical Modeling and Analyses

- Introduction to probabilistic models:
- Bivariate analysis, scatter plots,
- Simple linear regression model and correlation analysis;
- Basics of estimation and confidence interval;
- Testing of hypothesis (z-test; t-test);
- Statistical inference in decision making;
- Quantitative reasoning exercises using statistical modeling.

Recommended Books:

1. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. "Discrete Mathematics and its Applications" by Kenneth H. Rosen. 3. "Discrete Mathematics with Applications" by Susanna S. Epp.
3. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
4. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
5. "Introductory Statistics" by Prem S. Mann.
6. "Applied Statistical Modeling" by Salvatore Babones.
7. "Barrons SAT" by Sharvon Weiner Green, M.A and Ira K. Wolf.

ENG-502 EXPOSITORY WRITING Credit Hours: 3 (3 – 0)

General course

Pre-Requisite: Functional English

Objectives:

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation of the pre-requisite course, Functional English, this course will enhance students' abilities 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.

Contents:

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

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.)
- Proof reading (fine-tuning of the draft)
- Peer review and feedback (providing and receiving critique)

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)

4. Different 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)

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

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 evidences (quoting, paraphrasing, and summarizing)
- Avoiding plagiarism (ethical considerations and best practices)

Suggested Practical Activities (Optional)

As part of the overall learning requirements, students will be required to build a writing portfolio having a variety of expository texts and present the same at the end of the course showcasing proficiency in expository writing.

Recommended Books:

1. "The St. Martin's Guide to Writing" by Rise B. Axelrod and Charles R. Cooper.
2. "They Say/1Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein.
3. "Writing Analytically" by David Rosenwasser and Jill Stephen.
4. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup.
5. "The Elements of Style" by William Strunk Jr. and E.B. White.
6. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer.

IS-534 UNDERSTANDING OF QURAN-II (FEHM- E- QURAN-II) Credit Hours: 1(0-1)

General Education Course

Pre-Requisite: **Fehm- e- Quran-I**

Objective:

The course aims to develop students' ability to comprehend hundreds of Quranic sentences and verses directly while achieving an understanding of approximately 80–85% of the vocabulary and sentence structures on each page of the Holy Quran. It seeks to build proficiency in both the fundamental and advanced linguistic aspects of Quranic Arabic, enabling students to recognize and differentiate between various verb forms, including past, present, and imperative.

Course Learning Outcomes:

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

Provision of material, content and books

1. Paper book: All volumes are available in printed book form.
2. Tutorial videos: Teaching video of each lesson available on YouTube.
3. Confirmation Videos: A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
4. A flipbook: A flipbook edition is also accessible.
5. Helping material: Helping material for the teachers like quizzes, question papers and images is available on website.

PHY-504 ELECTRICITY AND MAGNETISM Credit Hours: 3(2-1)

Major course

Pre-requisite: Mechanics, Calculus I

Objectives: The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields and interactions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Course Learning Outcomes

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

- 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.

Contents:

Electrostatics: Electric Charge, Conductors and Insulators, Coulomb's Law, Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to different Charge Distribution (line, disc, ring), Electric Dipole in an Electric Field, Electric Flux, Gauss' Law and its Applications in Planar, Spherical and Cylindrical Symmetry.

Electric Potential: Electric potential, Electric potential energy**,** Equipotential Surfaces, Potential due to a Point Charge and a Group of Point Charges, Potential due to an Electric Dipole, Potential due to a Charge Distribution, Relation between Electric Field and Electric Potential.

Magnetic Field and Magnetic Force: Crossed Electric and Magnetic Fields and their Applications, Hall Effect, Magnetic Force on a Current Carrying Wire, Torque on a Current Loop, Magnetic Dipole Moment, Magnetic Field Due to a Current, Force between two Parallel Currents, Ampere's Law, Biot- Savart Law: Magnetic Field due to a Current, Long Straight Wire carrying Current, Solenoids and Toroids, A current-carrying Coil as a Magnetic Dipole,

Electro Magnetic Induction: Inductance, Faraday's Law of Induction, Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductances, Self-Inductance, RL Circuits, Energy Stored in a Magnetic Field, Energy Density, Mutual Induction.

Alternating Fields and Currents: LC Oscillations, Damped Oscillations in an RLC circuit, Alternating Currents, Forced Oscillations, Resistive, Capacitive, and Inductive Loads, RLC series Circuit, Power in AC Circuits, Transformers, Gauss' Law for Magnetism, Induced Magnetic Fields, Displacement Current, Spin & Orbital Magnetic Dipole Moment, Diamagnetism, Paramagnetism, Ferromagnetism, Hysteresis.

Experiments:

1. To determine the frequency of AC supply.
2. Measurement of high resistance using a neon flash bulb and a capacitor.
3. Measurement of low resistance coil by a Cary Foster Bridge.
4. Conversion of a moving-coil galvanometer into voltmeter and ammeter.
5. Calibration of an ammeter using a potentiometer.
6. Calibration of a voltmeter using a potentiometer.
7. To determine (i) current sensitivity and (ii) charge sensitivity of a ballistic galvanometer
8. Comparison of capacities of two capacitors by a ballistic galvanometer.
9. To determine the self-inductance of a coil by Rayleigh's Method.
10. To determine the self-inductance of a coil by Anderson's Method.
11. To determine the coefficient of mutual inductance of a pair of a coils.
12. Measurement of resistance using neon flash bulb and condenser
13. To convert a Weston type galvanometer into an ammeter of a given range

14. To study the BH curve and measuring the magnetic properties
15. Determination of the resonance frequency, band width and quality factor of a series RLC (acceptor) circuit and parallel RLC (rejecter) circuit.
16. Measurement of DC and AC voltages by Cathode ray oscilloscope.

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010.
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison Wesley, 4th ed. 2008.

PHY-505 MODERN PHYSICS Credit Hours: 3(2-1)

Major course

Pre-requisites: Mechanics, Electricity and Magnetism

Objective:

To understand the non-classical aspects of Physics, the emphasis is on the applications of Quantum Physics in microscopic-scale Physics, atomic and molecular structure and processes.

Course Learning Outcomes:

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

- 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.

Contents:

Relativity: Special Relatively, Time Dilation, Doppler Effect, Length Contraction, Twin Paradox, Electricity and Magnetism, Relativistic Momentum, Mass and Energy, Energy and Momentum, The Michelson–Morley experiment, Einstein's principle of Relativity, The Lorentz transformation.

Wace-Particle Duality: Electromagnetic waves, Blackbody Radiation, Photoelectric effect, what is Light? X –rays, X-rays Diffraction, Compton Effect, Pair Production, Photons and Gravity. de-Broglie waves, waves of probability, Phase and Group velocities, Particle Diffraction, Particle in a Box, Uncertainty principle, Quantum Interference.

Quantum Mechanics: Classical Mechanics is an approximation of Quantum Mechanics, The Wave Equation, Schrodinger's Equation: Time Dependent form, Linearity and Superposition, Expectation values, Operators, Schrodinger's Equation: Steady-state form, Particle in a Box, Finite potential well, Tunnel effect, Applications of tunneling, Harmonic Oscillator, Schrodinger's Equation for hydrogen atom, Separation of variables, Quantum numbers, Principle Quantum number, Orbital Quantum number, Magnetic Quantum number, Electron probability Density, Radiative Transitions, Selection Rules, Zeeman Effect

Atomic Models and Quantum Concepts: Thomson atomic model (electron exists), Rutherford atomic model (nucleus exists) and Bohr atomic model (quantization of energies inside an atom), direct confirmation of quantization through Franck-Hertz experiment and spectroscopy, working of electron microscopes.

Nuclear Structure: Nuclear Composition, Some Nuclear Properties, Stable Nuclei, Binding energy, Liquid Drop Model, Shell Model. Meson Theory of Nuclear Forces.

Nuclear Transformation: Radioactive Decay, Half-Life, Radioactive Series, Alpha Decay, Beta Decay, Gamma Decay, Cross section, Nuclear Reactions, Nuclear Fission, Nuclear Reactors. Nuclear Fusion in Stars, Fusion Reactors.

Experiments:

1. To study the characteristics of photoelectron emission and determination of Planck's constant using a photocell.
2. Determination of ionization potential of mercury.
3. Variation of Photoelectric current with intensity of light.
4. Measurement of the Thermal E.M.F. of a thermocouple as a function of temperature between its Hot and Cold junctions.
5. Determination of the temperature co-efficient of resistance of a wire.
6. Determination of the Mechanical Equivalent of Heat J by Callendar and Barne's constant flow apparatus with heat loss compensation.
7. Determination of Stefan's constant.
8. Calibration of a thermocouple by potentiometer.

Recommended Books:

1. Arthur Beiser, "Concepts of Modern Physics", McGraw-Hill, 7th ed. 2015.
2. R.A. Serway, C.J. Moses and C.A. Moyer, "Modern Physics", Brooks Cole, 3rd ed. 2004.
3. Paul A. Tipler and Ralph A. Llewellyn, "Modern Physics", W H Freeman and Company 6th ed. 2012.
4. R. M. Eisberg and R. Resnick, "Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles", John Wiley, 2nd ed. 2002.

MATH-521 VECTOR CALCULUS Credit Hours: 3(3-0)

Major course

Prerequisites: Mechanics**,** Calculus I and II

Objectives:

This course provides a comprehensive understanding of vector algebra and vector calculus and their applications in physics. It develops students' ability to analyze scalar and vector fields, apply vector operations and differential operators (gradient, divergence, and curl), evaluate line, surface, and volume integrals, and use Green's, Gauss's, and Stokes' theorems to solve problems in mechanics and electromagnetism.

Course Learning Outcomes:

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

- 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.

Contents:

Foundations of Vector Algebra: Scalar and vector quantities, laws of vector algebra, Composition of vectors, Rectangular or orthogonal unit vectors, Orthogonal resolution of vectors and direction cosines, Position vectors and displacement vector,

Vector Products and Vector Triples: Product of vectors, Triple product of vectors, Scalar triple product

Vector Field Theories and applications: Physical significance of scalar triple product and Vector triple product, Scalar and vector field, solenoidal field and conservative field, application to Gauss law, Coulomb law and electric potential.

The Gradient and Scalar Field Dynamics: Gradient of a scalar field in cartesian coordinates, Physical significance of grad Φ, Geometrical interpretation of grad Φ,

Vector Differential Calculus – Divergence, Curl, and Flux: Physical significance of divergence of a vector, Flux of a vector field, Divergence of a vector in cartesian coordinates, Gauss's divergence theorem, Curl of a vector field, Curl of a vector in cartesian coordinates, Line integral of a vector function, Surface integral of a vector function, Volume integral

Integral Theorems of Vector Calculus: Stoke's theorem, Green's theorem in a plane, Gauss's divergence theorem, application of line integral (Amperes law, work done by force and electric potential), application surface integral (Gauss law for Magnetism and Electrostatics), application of volume integral (total mass, charge and field).

Recommended books:

1. Schey, H. M. (2005). *Div, Grad, Curl, and All That: An Informal Text on Vector Calculus* (4th ed.). W. W. Norton & Company.
2. Griffiths, D. J. (2017). *Introduction to Electrodynamics* (4th ed.). Cambridge University Press.
3. Boas, M. L. (2006). *Mathematical Methods in the Physical Sciences* (3rd ed.). John Wiley & Sons.
4. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Academic Press.
5. Kreyszig, E. (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley & Sons.

MATH- 504 LINEAR ALGEBRA Credit Hours: 3(3-0)

Interdisciplinary course

Prerequisites: Calculus I

Objectives: Linear algebra is the study of vector spaces and linear transformations. The main objective of this course is to help students learn in rigorous manner, the tools and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences and develop mathematical skills needed to apply these to the problems arising within their field of study; and to various real-world problems.

Course Learning Outcomes

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

- Solve systems of linear equations using matrix methods.
- Apply vector spaces and linear transformations to physical problems.
- Analyze eigenvalues and eigenvectors in the context of physical systems.

Contents:

System of Linear Equations: Representation in matrix form. Matrices & Operations Introduction to matrices, matrix arithmetic, and operations. Row Reduction Techniques Echelon and reduced row echelon form (RREF). Matrix Inversion Finding the inverse of a matrix using elementary row operations. System Solutions, Gaussian elimination and the Gauss-Jordan method.

Determinants: Computing determinants, properties of determinants, and expansion of higher-order determinants.

Vector Spaces: Definition, core axioms, and illustrative examples. Subspaces Definition, examples, and testing for subspaces. Span & Independence Linear combinations, spanning sets, and linearly independent sets. Basis & Dimension Finitely generated vector spaces, finding bases, and determining the dimension of a vector space. Advanced Subspace Operations Intersections, sums, direct sums of subspaces, and quotient spaces.

Linear Transformations: Definition, kernel and range, matrix representation of a linear transformation, and application to physical coordinate shifts/rotations.

The Eigenvalue Problem and diagonalization: Characteristic equations, algebraic and geometric multiplicity, Conditions for diagonalizing matrices, powers of matrices.

Recommended Books:

1. Ch. W. Curtis, Linear Algebra, Springer 2004.
2. T. Apostol, Multi Variable Calculus and Linear Algebra, 2nd ed., John Wiley and sons, 1997.
3. H. Anton, C. Rorres , Elementary Linear Algebra: Applications Version, 10th Edition, John Wiley and sons, 2010.
4. S. Friedberg, A. Insel, Linear Algebra, 4th Edition, Pearson Education Canada, 2003.
5. S. I. Grossman, Elementary Linear Algebra, 5th Edition, Cengage Learning, 2004.

GC-5XX ARTS AND HUMANITIES ((INTRODUCTION TO HISTORY, INTRODUCTION TO PHILOSOPHY, INTRODUCTION TO MASS COMMUNICATION, INTRODUCTION TO PSYCHOLOGY) General Education Course Credit hours: 2 (2 – 0)

Course Content may be taken from the selected discipline (See on Page no. 65)

SOC-502 CIVICS AND COMMUNITY ENGAGEMENT Credit Hours: 2 (2 - 0)
General Education Course

Pre-Requisite: 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 essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.

Contents:

1. Civics and Citizenship:

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

2. State, Government and Civil Society:

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

3. Rights and Responsibilities:

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

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.

5. Advocacy and Activism:

- Public discourse and public opinion.

- Role of advocacy in addressing social issues.
- Social action movements.

6. Digital Citizenship and Technology:

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

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 societal harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

As part 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 capture the lived experiences and perspectives of diverse individuals.

2. Community Event Planning: Students can organize a community event or workshop that addresses a specific issue or fosters community interaction. This could be a health fair, environmental cleanup, cultural festival, or educational workshop.

3. Service-Learning: Students 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 populations.

4. Cultural Exchange Activities: Students 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:

1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education.
2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman.
3. "Engaging Youth in Civic Life" by James Youniss and Peter Levine.
4. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson.
5. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby.
6. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian.

PS-526 IDEOLOGY AND CONSTITUTION OF PAKISTAN Credit Hours: 2 (2–0)

General Course

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 Pakistani citizens to enable them function in a socially responsible manner.

Contents:

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 Indin 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 for separate homeland for Muslims of British India.
2. **Two-Nation Theory:**
   - Evolution of the Two-Nation Theory (Urdu-Hindi c ontroversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937
   - Lahore Resolution 1940)
   - Role of communalism and religious differences.
3. **Introduction to the Constitution of Pakistan:**
   - Definition and importance of a constitution.
   - Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949)
   - Overview of constitutional developments in Pakistan.
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 on federalism.
5. **Fundamental Rights, Principles of Policy and Responsibilities:**
   - Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
   - Overview of Principles of Policy (Articles 29-40).
   - Responsibilities of the Pakistani citizens (Article 5).
6. **Constitutional Amendments:**
   - Procedures for amending the Constitution.
   - Notable constitutional amendments and their implications.

Recommended Books:

1. "The Idea of Pakistan" by Stephen P. Cohen.
2. "Ideology of Pakistan" by Javed Iqbal.
3. "The Struggle for Pakistan" by 1.H. Qureshi.
4. "Pakistan the Formative Phase" by Khalid Bin Sayeed.
5. "Pakistan: Political Roots and Development" by Safdar Mahmood.
6. "Ideology of Pakistan" by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jalal.

PHY-508 **ELECTRONICS-I** **Credit Hours: 3(2-1)**

Major course

Pre-requisites: Modern Physics-I

Objective:

This course provides a foundation in electronic circuit analysis, semiconductor devices, transistors, oscillators, and operational amplifiers. It develops students' ability to analyze, design, and solve practical analog electronic circuits using fundamental electronic principles.

Course Learning Outcomes:

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

- 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.

Contents:

DC Circuit Analysis: Series and parallel circuits, Voltage divider rule, current divider rule, Superposition theorem, Thevenin's Theorem, Norton's Theorem. ,

Diodes and their applications: Semiconductors, Conductors and Insulators; N and P-Type materials; The PN-Junction and it's Basing; Diode Models, Half-wave Rectifier; Full-wave Rectifier (Simple and Bridge); Clipper and Clamper Circuits; Voltage Multiplier circuits; Zener Diodes; Varactor Diode; Optical Diodes (LED and Photodiode).

Bipolar junction transistor.

Basic Transistor Operation; Transistor Characteristics and Parameters (Alpha and Beta Parameters, Current and Voltage Analysis, Characteristic Curves, DC Load Line, Variation of Beta with Temperature); Transistor as an Amplifier: Transistor as a Switch; Photo transistor, The DC Operating Point; Voltage Divider Bias; Base Bias; Emitter Bias, Emitter feedback bias, Collector Feedback Bias, Transistor AC Equivalent Circuits (r-Parameters, h – parameters); Common Emitter Amplifier DC and AC Analysis, Common Collector Amplifier, Darlington Pair; Common Base Amplifier.

Field Effect Transistors: Junction FET; MOSFET; Operation and Construction; Biasing (Self Bias and Voltage Divider Bias); Insulated Gate Bipolar Junction Transistor (IGBT), Common Source and Common Drain Amplifiers (DC and AC Analysis, Input Resistance, Voltage and Current Gain, Frequency Response etc), Common Gate Amplifier.

Oscillators: Introduction; Barkhausen Criterion; Feedback Oscillators; positive feedback condition for oscillation, startup conditions, RC Oscillators (Wien Bridge Phase, Shift Oscillator and T-twin oscillator); LC Oscillators (Colpitts, Crystal and Hartley Oscillators).

Operational Amplifiers: Parameters and Characteristics of Operational amplifier, The Inverting and Non-inverting Op Amp, The Differential Amplifier; Summing Amplifier, Comparator, voltage follower Circuit.

Problem Solving Approach: Students will be given assignment to solve any practical problem using the knowledge gained from this course.

Experiments / Practical

1. Diode characteristics and rectifiers
2. BJT Transistor characteristics
3. BJT amplifiers
4. BJT oscillators and vibrators
5. JFET characteristics
6. MOSFET circuits

Recommended Books:

1. T.L.Floyd' Electronic Devices 9/e Prentice Hall (2012) Main Text Book.
2. A.P. Malvino' Electronic Principles' 7/e with CD-Rom Glencoe/ McGraw-Hill (2007).
3. D.A. Bell' Electronic Devices and Circuits'4/e Prentice Hall (1999).
4. C.J. Savant Jr. M.S. Roden and G.L Carpenter' Electronic Design Circuit and System' The
5. Benjamin Publishing Co., California (1994).
6. Robert L. Boylestad. Introductory Circuit Analysis, 12th /e (2012) **Prentice Hall**
7. B. Streetman and S. Banerjee "Solid State Electronics Devices", Prentice Hall, 6th ed. 2005.
8. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, 1998.

PHY-510 CLASSICAL MECHANICS Credit Hours: 3(3-0)

Major course

Pre-requisites: Introductory Mechanics

Objective:

This course provides a foundation in advanced classical mechanics, emphasizing central force motion, Lagrangian and Hamiltonian dynamics, non-inertial systems, and rigid body motion, while developing the analytical skills required to model and solve complex mechanical problems.

Course Learning Outcomes:

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

- Apply Newton's laws of motion to analyze the dynamic of particles and rigid body.
- Solve problems in Lagrangian and Hamiltonian mechanics
- Analyze system under consevative and non conservstive forces

Contents:

Central Force Motion: Review of Newtonian Mechanics, Central Force, the two-body problem and reduce mass, General properties of Central force motion, effective potential and classification of orbits, Kepler's laws, stability of circular orbits, Scattering in a Central Force Field, hyperbolic orbits and Rutherford scattering, scattering cross-sections. Center of mass co-ordinate system

The Lagrange Formulation of Mechanics: Degree of freedom and Constraints, Generalized coordinates, Virtual work, D'Alembert's principle, Lagrange's Equations and applications, Equivalence of Lagranges 's and Newton's Equation

Hamiltonian Dynamics, Hamilton's principle, Lagrange's equation from Hamilton's principle, integrals of motion, non-conservative system and generalized potential, the Hamiltonian of a dynamical system(Legender transformation), Hamilton's canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.

Motion in Non-Inertial Systems: Accelerated translational co-ordinate system, dynamics in rotating co-ordinate system, Coriolis Force, motion of a particle near the surface of the earth

The Motion of Rigid Bodies: The Euler Theorem, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, Euler's Angles, motion of a torque-free symmetrical top, stability of rotational motion.

Recommended Books:

1. T. L. Chow, "Classical Mechanics", John Wiley, 1995.
2. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, 5th ed.2004

MATH-509 DIFFERENTIAL EQUATIONS Credit Hours: 3(3-0)

Major Course

Prerequisites: Calculus I

Objectives:

To introduce students to the formulation, classification of differential equations and existence and uniqueness of solutions. To provide skill in solving initial value and boundary value problems. To develop understanding and skill in solving first and second order linear homogeneous and nonhomogeneous differential equations and solving differential equations using power series methods. To understand the skill used in solving partial differential equations and their applications.

Course Learning Outcomes

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

- 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.

Contents:

Introduction to differential equations: Definitions and terminology, Initial-value problems, Linear and nonlinear equations, general solution, Particular solution, explicit solution, implicit solution, Differential equations as mathematical models.

First order differential equation: Basic concepts, formation and solution of differential equations. Separable variables, Exact Equations, Homogeneous Equations, Linear equations, integrating factors. Some nonlinear first order equations with known solution, differential equations of Bernoulli and Ricaati type, Clairaut equation. Applications of first order differential equations.

linear differential equations of higher order: Initial value and boundary value problems, linear dependence and independence, solutions of linear equations, constructing a second solution from a known solution, homogeneous linear equations with constant coefficients, undetermined coefficients, variation of parameters, applications of second order ODEs (simple harmonic motion, damped and forced oscillators, electrical circuits and springs)

Differential equations with variable coefficients: Cauchy-Euler equation, power series solution of differential equations – solutions about ordinary and singular points-Legendre's and Bessel's equations as examples,

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 particular solutions (first order, inhomogeneous, second order), characteristics and existence of solutions, uniqueness of solutions, separation of variables in Cartesian coordinates, superposition of separated solutions, separation of variables in curvilinear coordinates,

Recommended Books:

1. Dennis G. Zill and Michael R., Differential equations with boundary-value problems by Cullin 5th Edition Brooks/Cole, 1997.
2. William E. Boyce and Richard C. Diprima, Elementary differential equations and
3. boundary value problems, Seventh Edition John Wiley & Sons, Inc
4. Apostol, Multi Variable Calculus and Linear Algebra, 2nd ed., John Wiley sons, 1997.

CHEM- 500 CHEMISTRY Credit Hours: 3 (2-1)

General Course (Natural Science)

Objective:

To study the basic concepts of chemistry including periodic table, hydrogen and hydrides, electrochemical cells, hydrocarbons, organic polymers, Chromatography and spectroscopy.

Contents:

Atomic Structure: Structure of atom, Quantum Numbers, Heisenberg's Uncertainty Principle, Ionization Potential, Electronegativity and Electron affinity.

Periodic Table and Periodicity: Development of Modern Periodic Table, Periodicity of Properties electronic configuration and classification of elements.

Chemical Bonding: Nature and types of chemical bond, Ionic, Covalent, Coordinate Covalent, Sigma, Pi, Polar and Non-polar bonds.

Basic Concepts of Organic Chemistry: Introduction, Functional groups, resonance effect, inductive effect, hydrogen bonding, Tautomerism.

Recommended Books:

1. M. Younas, Organic Spectroscopy and Chromatography, Lahore Ilmi Kitab Khana, 1998
2. M. Younas, A Textbook of Organic Chemistry, Publication: Lahore Ilmi Kitab Khana, 2011
3. M. Zafar Iqbal, Text Book of Inorganic Chemistry, Ilmi Kitab Khana, 1990.
4. JohnE. Mcmurry, Organic Chemistry, Mary Finch, 8th Edi., 2012.
5. Rehman, A., Text book of Organic Chemistry. Karwan book house.
6. March, J., Advanced Organic Chemistry. John Wiley and sons.
7. Pine. , S.H., Organic Chemistry, McGraw Hill, Inc.
8. Sykes, F., Organic reaction Mechanism.
9. *Younas, M., Organic spectroscopy, A.H. Publisher*.
10. Vogel, A.I, Organic analysis, Longman Green & Co.

ENT-508 ENTREPRENEURSHIP Credit hours: 2 (2 – 0)

General Education Course

Objectives:

This course develops an entrepreneurial mindset by equipping students with the knowledge and skills to identify business opportunities, develop business plans, manage finances, and apply marketing, innovation, and team-building strategies to establish and manage successful ventures.

Contents:

1. Introduction to Entrepreneurship:

- Definition and concept of entrepreneurship.
- Why to become an entrepreneur?
- Entrepreneurial process.
- Role of entrepreneurship in economic development.

2. Entrepreneurial Skills:

- Characteristics and qualities of successful entrepreneurs (including stories of successes and failures).
- Areas of essential entrepreneurial skill and ability such as creative and critical thinking.
- Innovation and risk taking abilities etc.

3. Opportunity Recognition and Idea Generation:

- Opportunity identification, evaluation and exploitation;
- Innovative idea generation techniques for entrepreneurial ventures.

4. Marketing and Sales

- Target market identification and segmentation;
- Four P's of Marketing.
- Developing a marketing strategy.
- Branding.

5. Financial Literacy:

- Basic concepts of income, savings and investments.
- Basic concepts of assets, liabilities and equity.
- Basic concepts of revenue and expenses.
- Overview of cash-flows.
- Overview of banking products including Islamic modes of financing.
- Sources of funding for startups (angel financing, debt financing, equity financing etc.).

6. Team Building for Startups:

- Characteristics and features of effective teams.
- Building and effective leadership for startups.

7. Regulatory Requirements to Establish Enterprises in Pakistan:

- Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.).
- Intellectual property rights and protection.
- Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms.
- Taxation and financial reporting obligation.

Suggested Practical Activities (Optional)

As part of the overall learning requirements, students shall be tasked with creating and presenting a comprehensive business plan at the end of the course for a hypothetical or real business idea. This practical exercise shall allow them to apply the knowledge, skills and competencies acquires in the course to develop a feasible business plan.

Recommended Books:

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland.
2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko.
3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.
4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.
5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valérie Ohlsson.

PST - 501 PAKISTAN STUDIES Credit hours: 2 (2 – 0)

General Education Course

Objectives:

This course provides a comprehensive understanding of Pakistan's geographical, historical, cultural, and political development. It enables students to critically examine the nation's evolution, identity, and contemporary challenges while fostering an informed perspective on its future 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.

Contents:

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

2. Political History of Pakistan:
- Formative phase.
- Military interventions and democratic transitions.

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

4. Society and Culture of Pakistan:
- Socio-cultural diversity.
- Languages and literature of Pakistan.

5. Economic Development of Pakistan:
- Agriculture and industrial sectors of Pakistan.
- Economic challenges of Pakistan.

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

Recommended Books:

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Dermand 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
4. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
5. "Constitutional and Political History of Pakistan" by Hamid Khan
6. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
7. "Pakistan: A Modern History" by lan Talbot
8. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
9. "Physical Geography of Pakistan" by Umar Jahangir
10. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan 12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke

GC-5XX SOCIAL SCIENCES (FUNDAMENTAL OF GEOGRAPHY, FUNDAMENTAL OF DISASTER MANAGEMENT, INTRODUCTION TO INTERNATIONAL RELATIONS, INTRODUCTION TO SOCIOLOGY, INTRODUCTION TO POLITICAL SCIENCE, FUNDAMENTALS OF ECONOMICS)

General Education Course **Credit hours: 2 (2 – 0)**

Select only one course, course contents may be taken from the selected discipline (See on page no. 68)

PHY-602 **ELECTRONICS- II** **Credit Hours: 3(2-1)**

Major Course

Pre-requisites: Electronics-I

Objectives:

This course provides a foundation in digital electronics, microprocessors, microcontrollers, and embedded systems. It develops students' ability to analyze and design digital logic circuits, apply memory and processor architectures, program Arduino-based systems, and develop embedded solutions for real-world sensing, control, and automation applications.

Course Learning Outcomes:

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

- 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.

Contents:

Review of Number Systems: 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, Don't care condition, BCD and Gray code, 1's and 2's complements, addition and subtraction of binary numbers.

Combinational Logic Circuit: Logic circuits based on logic gates, adder, subtractor, 4 bit adder/subtrator, encoder, decoder, multiplexer and demultiplexer.

Sequential Logic Circuit: Latch and Flip-flops (RS, D, JK, and Master slave flip flop), Shift Register, Counters (Ring, Ripple, up-down), A/D and D/A Converters.

Memory Devices: ROM (all types), RAM, (Static and dynamic), Memory mapping techniques, Microprocessors architecture (8088, 8086), Addressing modes, Instruction set and their types.

Micro-controllers: Arduino Family of Microcontroller boards (Uno, Mega, Nano, Pico), scratch programing using mBlock, Arduino IDE.

Embedded System: Introduction to Embedded systems, DC Motor drivers, Stepper Motor Drivers, Motion and position control system, design a system to control water level and flow, automatic bottle filling system, use of weight, pressure and temperature sensors in embedded systems.

Experiments:

1. To demonstrate the operation and characteristics of TTL Logic Gate and to show how, It can be used to perform any three basic logic functions.
2. To demonstrate the operation and characteristics of CMOS Logic Gate and to show how it
3. can be used to perform any three basic logic functions.
4. To demonstrate the operation of XOR Logic Gate and XNOR Logic To demonstrate the
5. operation and characteristics of a set and rest (Latch) Flip Flop.
6. To demonstrate the operation and characteristics of a D-type Flip Flop and storage register.
7. To demonstrate the operation and characteristics of a binary counter.
8. Arduino Uno motion and position control system
9. To demonstrate the operation of Decoder gate.
10. To demonstrate the operation of Decoder.
11. To demonstrate the operation of Multiplexer.

Recommended Books:

1. T.C Bartec' **Digital System Design and Micro processor'** (NBF) Latest Edition
2. Brey, "The Intel Microprocessors: Architecture, Programming and Interfacing", Merril, 2nd ed. 1991.
3. M. .Morris Mano **'Digital Logic and Computer Design** 'Prentice Hall Latest Edition
4. M. M. Mono, "Digital Logic and Computer Design", Prentice Hall, 1995.

5. R. Tokheim, "Digital Electronics", McGraw Hill, 7th ed. 2007.
6. R.L Tokheim **'Digital Electronics: Principles and Applications'** 6/e, McGraw-Hill (2003)
7. T. Wilmshurst, "The Design of Small-Scale Embedded Systems", Palgrave, 2001.
8. T.L Floyd '**Digital Fundamental'** 10th /e Prentice Hall (2013)

PHY-604 ELECTROMAGNETIC THEORY Credit Hours: 3(3-0)

Major course

Pre-requisites: Electricity and Magnetism, Calculus-II

Objective:

This course provides a foundation in classical electrodynamics, emphasizing Maxwell's equations, electrostatics, magnetostatics, electromagnetic waves, and boundary-value problems while developing the analytical skills required to solve advanced electromagnetic field problems.

Course Learning Outcomes

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

- 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.

Contents:

Mathematical Foundations & Recapitulation

Review of vector calculus: Del operators, gradient, divergence, and curl. Recapitulation of fundamental field vectors: Electric field intensity **E**, Electric displacement **D**, Magnetic induction **B**, and Magnetic intensity **H**. Coulomb's Law, Gauss's Law, Biot-Savart Law, and Ampere's Law in free space.

Electrodynamics & Maxwell's Equations

Electromotive force; Faraday's Law of induction. The Equation of Continuity (Conservation of Charge). Maxwell's modification of Ampere's Law (Displacement Current).

Maxwell's Equations: Differential and integral formulations in vacuum and in matter. Conservation Laws: Poynting's theorem for energy conservation and the physical significance of the Poynting vector.

Advanced Electrostatics & Special Boundary Techniques

Electrostatics in Free Space: Poisson's and Laplace's equations; Uniqueness Theorems. Dirichlet and Neumann boundary conditions; Solutions to Laplace's Equation: Separation of variables in Cartesian, Spherical Polar, and Cylindrical coordinates. The Method of Charge Images; electric dipole and multipole expansion

Time Dependent Electromagnetic Fields: Potential Function and Electromagnetic Fields; Retarded Potential; Limitations of Static Potentials; Lienard-Wiechart Potentials; Field of a Uniformly Moving Potential Charge; Radiation by Accelerated Charges.

Magnetostatics: Lorentz force law; motion of charged particles in electric and magnetic fields; current density and equation of continuity; Ampère's circuital law and applications; magnetic vector potential; magnetic boundary conditions; magnetic dipole and multipole expansion.

Recommended Textbooks:

1. **David J. Griffiths**, *Introduction to Electrodynamics*, 5th Edition, Cambridge University Press, 2024.
2. **Paul Lorrain and Dale R. Corson**, *Electromagnetic Fields and Waves*, 3rd Edition, CBS Publishers.
3. **William H. Hayt and John A. Buck**, *Engineering Electromagnetics*, 9th Edition, McGraw-Hill.
4. **Matthew N. O. Sadiku**, *Elements of Electromagnetics*, 7th Edition, Oxford University Press.

PHY-605 MATHEMATICAL METHODS OF PHYSICS-I Credit Hours: 3(3-0)

Major course

Pre-requisite: Mechanics, Differential Equations, Linear Algebra

Objective(s): The course aims at developing understanding about fundamental concepts of PDEs theory, identification and classification of their different types, how they arise in applications, and analytical methods for solving them.

Course Learning Outcomes

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

- 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

Contents:

Vector. Vector Integration; Line, Surface and Volume Integrals; Green's Theorem in the plane: Gauss's Divergence Theorem; Stokes's Theorem; Curvilinear Coordinates; Orthogonal Curvilinear Coordinates; Representation of Gradient.

Fourier Analysis. Definition and Examples of Fourier Series; Half-range Expansions; Complex form of Fourier Series; Physical Applications (i.e., Analysis of Periodic Wave forms); Fourier Integral Theorem; Sine and Cosine Transforms; Complex Fourier Transform; Properties of Fourier Transform (Linearity, Time Shift, Frequency Shift, Scaling and Symmetry Properties) Convolution integral theorem.

The Laplace Transform. Definition; Laplace Transform of Elementary Functions; Properties of Laplace Transform; Inverse Laplace Transform and its Properties; The Convolution Theorem; Application to the Solution of Differential Equations with Constant Coefficients

Complex algebra: functions of a complex variable, Cauchy-Riemann conditions, analytic function, integration of complex functions, Cauchy's theorem, Harmonic function, Polar form of harmonic function

Tensor calculus: Introduction to basic concepts and laws of tensor used in tensor calculus and its applications

Recommended Books:

1. G.B. Arfken and H.J. Weber "Mathematical Methods for Physicists" 6/e Academic Press (2005).
2. M.L. Boas "Mathematical Methods in the Physical Science" 3/e John Wiley (2005).
3. S.H. Hassani " Mathematical Physics: A Modern Introduction to its Foundation" Springer (1999).
4. H.Jefreys and B. Jeffreys " Methods of Mathematical Physics" 3/e Cambridge University Press (1999).
5. E. Kreyszig" Advanced Engineering Mathematics" 9/e John Wiley (2006).

PHY-637 SCIENTIFIC INQUIRY AND RESEARCH METHODS Credit Hours: 3 (3–0)

Interdisciplinary course

Objectives:

This course introduces students to the principles of scientific inquiry, research design, and modern research practices. Students will learn how scientific knowledge is generated, evaluated, communicated, and applied. The course covers research methodologies, literature review techniques, data collection and analysis, scientific writing, research ethics, and presentation of research findings.

Course Learning Outcomes:

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

- Design and conduct scientific experiments to test hypotheses.
- Analyze and interpret experimental data using statistical methods.
- Communicate scientific findings through written reports and presentations.

Contents:

1: Introduction to Scientific Inquiry

Scientific thinking and reasoning, Scientific inquiry process, Role of observation, experimentation, and theory, Scientific methods (Observation, Problem identification, Hypothesis development, Experimentation, Analysis, Conclusion), Characteristics of good scientific research

2: Research Fundamentals

Types of research (Basic research, Applied research, Experimental research, Descriptive research, Analytical research), Research paradigms, Variables and measurements, Research problems and objectives, Formulating research questions, Development of hypotheses

3: Literature Review and Scientific Information Search

Importance of literature review (Searching scientific literature, Scientific databases), Reading and evaluating research articles, Citation management tools, Avoiding plagiarism, Referencing styles

4: Research Design and Methodology

Experimental design, Sampling methods (Random sampling, Stratified sampling, Systematic sampling), Data collection techniques (Surveys, Interviews, Experiments, Observations), Reliability and validity, Control variables and experimental errors

5: Data Analysis and Interpretation

Types of data, Data organization and presentation, Basic statistical concepts (Mean, Median, Standard deviation, Correlation, Regression), Graphical representation of data, Introduction to data analysis software (Microsoft Excel, SPSS, Origin)

6: Scientific Writing and Communication

Structure of a scientific paper (Title, Abstract, Introduction, Methodology, Results, Discussion, Conclusion, References), Research proposal writing, Thesis/report writing, Scientific poster preparation, Oral presentation skills

7: Research Ethics and Intellectual Property

Research ethics principles, Responsible conduct of research, Plagiarism and academic misconduct, Authorship and publication ethics, Intellectual property rights, Copyright and patents

Recommended Books:

1. Research Methodology: Methods and Techniques
2. The Craft of Research
3. Scientific Writing and Communication
4. Introduction to Research Methods in Education

PHY-638 **MEDICAL PHYSICS** **Credit Hours: 3(3-0)**

Interdisciplinary Course

Objectives:

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

- Describe the applications of physics in medical diagnostics and therapy.
- Analyze the interaction of radiation with biological tissues.
- Apply the principles of medical imaging and radiation therapy.

Contents:

Introduction to Medical Physics: Overview of Medical Physics, Role of physicists in healthcare settings, Ethical considerations in medical physics

Applications of Physics in Medical Diagnostics and Therapy: Medical Imaging: X-ray Imaging (Radiography, CT), MRI (Magnetic Resonance Imaging), Ultrasound Imaging Nuclear Medicine (PET, SPECT), Optical Imaging Techniques.

Radiation Therapy: Principles of Radiation Therapy, Types of Radiation Therapy (External Beam, Brachytherapy), Dosimetry and Radiation Treatment Planning, Radiation Shielding in Therapy Rooms

Radiation Interaction with Biological Tissues: Types of Ionizing Radiation (Alpha, Beta, Gamma, X-rays), Interaction Mechanisms: Photoelectric Effect, Compton Scattering, Pair Production, Biological Effects of Ionizing Radiation: DNA Damage, Cell Death and Mutagenesis, Radiation-Induced Cancer Radiation Protection: Biological and Physical Shielding

Principles of Medical Imaging: Image Formation in X-ray, MRI, and Ultrasound, Signal Processing and Image Reconstruction, Quality Assurance in Medical Imaging, Dosimetry in Diagnostic Imaging, Contrast Agents in Imaging

Radiation Therapy Principles: Radiation Dose Calculation: Radiation Absorbed Dose and Dose Distribution, Measurement and Calibration of Radiation Beams.

Radiation Therapy Techniques: Intensity-Modulated Radiation Therapy (IMRT), Stereotactic Radiation Therapy, Brachytherapy Applications, Proton Therapy

Safety and Ethics in Medical Physics: Radiation Safety: Limits and Protocols, Regulatory Standards and Guidelines (e.g., IAEA, NCRP) Patient Safety in Medical Imaging and Radiation Therapy, Professional Ethics in Medical Physics

Emerging Trends in Medical Physics: Advances in Imaging Technologies (e.g., 4D Imaging, Hybrid Imaging), Particle Beam Therapy and its Applications, Artificial Intelligence in Medical Physics, Innovations in Radiation Dosimetry

Recommended books

1. Bushberg, J. T., Seibert, J. A., Leidholdt, E. M., & Boone, J. M. The Essential Physics of Medical Imaging. 4th ed. Wolters Kluwer.
2. Gibbons, J. P. Khan's The Physics of Radiation Therapy. 6th ed. Wolters Kluwer.
3. Attix, F. H. Introduction to Radiological Physics and Radiation Dosimetry. Wiley.
4. IAEA. Diagnostic Radiology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency.
5. IAEA. Radiation Oncology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency.
6. Sherer, M. A. S., Visconti, P. J., Ritenour, E. R., & Haynes, K. W. Radiation Protection in Medical Radiography. 9th ed. Elsevier.
7. Cherry, S. R., Sorenson, J. A., & Phelps, M. E. Physics in Nuclear Medicine. Elsevier.
8. Westbrook, C., Roth, C. K., & Talbot, J. MRI in Practice. 5th ed. Wiley.

PHY-617 COMPUTATIONAL PHYSICS Credit Hours: 3(2-1)

Interdisciplinary Course

Objective(s):

Introduction of computer languages. To know the use of computer in numerical analysis. Computer simulation and modeling.

Course Learning Outcomes

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

- Implement numerical methods to solve physical problems.
- Develop and use computational algorithms for simulating physical systems.
- Independently program computers using leading edge tools.

Contents:

1. Introduction to Computational Physics

Introduction to computational physics and its applications

- Role of computation in modern physics research
- Analytical vs numerical solutions
- Problem-solving approaches in computational physics
- Basics of algorithms and flowcharts
- Introduction to programming environments

2. Programming for Physicists

Programming concepts for scientific computing

- Variables, data types, operators
- Conditional statements and loops
- Functions and modular programming
- Arrays and data structures
- File handling and data processing

3. Numerical Methods

Numerical Solution of Equations

- Errors and accuracy in numerical calculations
- Root-finding methods:
  - Bisection method
  - Newton-Raphson method
  - Secant method

Numerical Differentiation and Integration

- Finite difference methods
- Numerical integration:
  - Trapezoidal rule
  - Simpson's rule
- Applications in physics problems

4. Linear Algebra and Computational Techniques

- Matrix operations
- Solving simultaneous equations
- Gaussian elimination
- LU decomposition
- Eigenvalues and eigenvectors
- Applications in physics

5. Computational Modeling and Simulation

Classical Physics Simulations

- Projectile motion simulation
- Harmonic oscillator

- Pendulum dynamics
- Planetary motion

Electromagnetic Simulations

- Electric and magnetic field calculations
- Particle motion in electromagnetic fields

Quantum Physics Applications

- Numerical solution of Schrödinger equation
- Particle in a box
- Quantum tunneling

6. Advanced Computational Methods

- Random numbers and Monte Carlo methods
- Statistical simulations
- Molecular dynamics basics
- Optimization techniques
- Introduction to parallel computing
- Use of scientific libraries

Recommended Books:

1. C.F Gerald & P.O Wheatley „ Applied Numerical Analysis' 7/e Pearson Education 2004.
2. S.C Chapra and R.P Canate‟ Numerical Methods for Engineers with Software and Programming. Applications „ 4/e mcgraw-Hill (2002).
3. M. Iqbal‟ An Introduction to Numerical Analysis‟ llmi Kitab Khanna, Lahore (1991).
4. S.A Bhatti & N.A Bhatti‟ A First Course in Numerical Analysis with C++', Shaharyar Publishers,Lahore (2002).

PHY-639 STATISTICAL MECHANICS Credit Hours: 3(3-0)

Major Course

Pre-Requisites: Classical Mechanics, Heat and Thermodynamics

Objective:

This course provides a foundation in statistical mechanics by relating microscopic particle behavior to macroscopic thermodynamic properties. It develops students' ability to analyze statistical ensembles, apply classical and quantum statistics, and solve problems involving particle and energy distributions in physical systems.

Course Learning Outcomes:

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

- Apply the principle of statistical mechanics to explain macroscopic properties of system
- Analyze the Behavior of the system in thermodynamic system
- Solve problems involving the distribution of particle and energy in statistical system

Contents:

Introduction to Statistical Mechanics: Statistical Basis, Probability, Permutation and combination, Macrostate and Microstate, Thermodynamic Probability, Most Probable state, Concept of cell in a compartment, Position space, Momentum space, Phase Space.

Statistical Ensembles: Microcanonical Ensemble. Canonical Ensemble, Grand canonical Ensemble, Partition Function and relation with Thermodynamic Variables;

Classical statistics: Maxwell-Boltzmann Statistics, Maxwell's law of Distribution of Molecular velocities, Mean velocity, Root mean square velocity and most probable velocity of molecules, Degree of freedom and law of Equipartition of Energy.

Quantum statistics. Bose-Einstein and Fremi-Dirac Statistical Systems; Examples of Thermodynamics of these Systems; Black Body Radiation; Gas of electrons in solids.

Recommended Books:

1. E. Mandl' Statistical Physics 2/e John Wiley, London (1988).
2. F. Reif' Fundamentals of Statistical and Thermal Physics' McGraw-Hill (1965).
3. B.N. Roy' Fundamentals of Classical and Statistical thermodynamics' John Wiley (2002)
4. S.K. Sinha' Introduction to Statistical Mechanics' Narosa Publishing House, Delhi (2005).
5. Brij Lal, N. Subrahmanyam, P.S hemne "heat thermodynamics and statistical physics", s.chand series (2011)

PHY-610 MATHEMATICAL METHODS OF PHYSICS-II Credit Hours: 3 (3-0)

Major course

Pre-requisite: Mathematical Methods of Physics-I

Objective:

Introduction to special functions and complex analysis

Course Learning Outcomes

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

- 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.

Contents:

The Gamma and Beta Functions. Definitions, basic properties, problems and their solutions

Advanced differential equations and their solution: Bessel Functions, Bessel Differential Equation and its Solution; Bessel Functions of First and Second Kind; Generating Function; Recursion Relations; Orthogonality and Normalization Properties of Bessel Functions of First Kind. Legendre Functions of First Kind, Legendre Differential Equation and its solution; Legendre Functions; Rodrigues's Formula; Generating Function; Recursion Relations; Orthogonality and Normalization Properties. Associated Legendre Functions**,** Introduction; Associated Legendre Functions,Hermite Functions,Hermite Differential Equation and its Solution; Rodrigues's Formula; Generating Function; Recursion Relations; Orthogonality and Normalization Properties,
Laguerre Functions,Laguerre Differential Equation and its Solution; Rodrigues's Formula; Generating Function;Recursion relations; Orthogonality and Normalization Properties.

Variational methods: Introduction to variational principles related to the physical contexts, Euler legrange's equation, Hamilton's principles related to the physical problems.

Recommended Books:

1. C.W Wong 'Introduction to Mathematical Physics: Methods & Concepts' Oxford University Press. (1995).
2. E. Saff and A, Snider 'Fundamentals of Complex Analysis with Applications to Engineering Science and Mathematics' 3/e Pearson Education (2003).
3. E.Butkov' Mathematical Physics' Addison-Wesley (1968).
4. A. Jeffrey' Advanced Engineering Mathematics' 3/e Academic Press (2002).
5. B.D. Gupta' Mathematical Physics' 3/e Vikas Publishing, New Delhi (2004).

PHY-612 QUANTUM MECHANICS-I Credit Hours: 3(3-0)

Major course

Pre-requisites: Modern Physics

Objective:

This course aims to provide students with a solid foundation in the principles and mathematical formalism of quantum mechanics, develop the ability to apply the Schrödinger equation to solve fundamental quantum systems, and enhance understanding of angular momentum, matrix mechanics, spin, energy quantization, and quantum entanglement for the analysis of microscopic physical phenomena

Course Learning Outcomes

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

- 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.

Formulism of quantum mechanics: Wave Function and interpretation of the Wave function, The Time Independent Schrödinger Equation, The Time-dependent Schrödinger Equation. The State of System Dynamic Variables and Operators, three picture of quantum mechanics, postulates of quantum mechanics, Dirac Notation, Operators, Complete concept of spaces (The Hilbert space, vector space and trigonometric space)

Application of Schrodinger wave equation: Application of Schrödinger equation, Step Potential, Potential Barrier (Refection and Transmission Coefficients), Square Well Potential, Infinite Potential Well and Linear Harmonic Oscillator.

Angular momentum and Matrix mechanics: Orbital Angular Momentum; The Eigenvalues and Eigen functions of L^2 and L_z; Matrix Representation of Angular Momentum Operators; Spin Angular Momentums; Total Angular momentum; The Addition of Angular momentums. Commutation relation of L^2, L_x, L_y and L_z. Energy quantization. Quantum entanglement.

Recommended Books:

1. B.H Bransden and C.I Joachain‟ Quantum Mechanics‟ 2/e Pearson Education.
2. J.S Townsend‟ A Modern Approach to Quantum Mechanics‟ University Science Books, Sausaabto, California.
3. W.Greiner‟ Quantum Mechanics: An Introduction „Springer-Verlarg (1989)
4. R.L Liboff„Introduction Quantum Mechanics‟ 4/e Pearson Education (2003)
5. I. Bialynicki-Birula.M.Cieplak and J. Kaminski‟ Theory of Quanta‟ Oxford University Press (1992)

PHY-640 ELECTRODYNAMICS AND SPECIAL RELATIVITY Credit Hours: 3 (3–0)

Major Course

Prerequisite: Electromagnetic Theory

Objective:

This course develops a comprehensive understanding of electromagnetic wave propagation, waveguides, cavity resonators, and the relativistic formulation of electrodynamics. It equips students with the analytical skills to analyze guided electromagnetic waves, apply special relativity to electromagnetic phenomena, and formulate Maxwell's equations using covariant tensor methods.

Course Learning Outcomes

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

- Apply the principle of electrodynamics to analyze e.m waves
- solve problems related to interaction of light and matter

- Analyze propagation of e.m waves in different media

Contents:

Electromagnetic Waves: The wave equation, Sinusoidal waves, Euler's formula, boundary conditions: the wave equation for **E** and **B**, monochromatic plane waves, energy and momentum in electromagnetic waves, Electromagnetic waves in matter, propagation through linear media, index of refraction,

Wave guides and Guided Waves: Waves Guided by Perfectly Conducting Parallel Plates (Transverse Electric Waves, Transverse Magnetic Waves and Transverse Electromagnetic Wave); Cylindrical Wave Guide, Rectangular and Circular Wave Guides (TE and TM mode analysis), Attenuation in Wave Guides, Elementary Concepts of Cavity Resonator, (Rectangular Circular and Spherical Cavity Resonators); Quality Factor of Rectangular Cavity Resonator, Wave Equations for the Grounded Dielectric Slab (TE and TM modes)

Electromagnetism and special relativity: Einstein Postulates; The Geometry of Space-Time; The Lorentz transformations and its Consequences; Addition of Velocities; Relativistic Momentum and Energy; Relativistic Kinetics; Relativistic Dynamics; Magnetism as a Relativistic Phenomenon; Lorentz Transformations of Electric and Magnetic fields.

Covariant formulation of vacuum electrodynamics: Four-Vectors, Four-current density of and Four-potential; The Electromagnetic Field Tensor; Electrodynamics in tensor Notation; Relativistic Potentials Covariant form of Maxwell's Equations; Equation of motion of a charged particle in an Electromagnetic field; Maxwell's equation from the principle of least action; The Energy-Momentum Tensor of Electromagnetic field.

Recommended Books:

1. **David J. Griffiths**, *Introduction to Electrodynamics*, 5th Edition, Cambridge University Press, 2024.
2. **Paul Lorrain and Dale R. Corson**, *Electromagnetic Fields and Waves*, 3rd Edition, CBS Publishers.
3. **Matthew N. O. Sadiku**, *Elements of Electromagnetics*, 7th Edition, Oxford University Press.
4. **John D. Jackson**, *Classical Electrodynamics*, 3rd Edition, Wiley (Reference).
5. **Wolfgang K. H. Panofsky and Melba Phillips**, *Classical Electricity and Magnetism*, 2nd Edition, Dover (Reference).

PHY-641 CONDENSED MATTER OF PHYSICS Credit Hours: 3(3-0)

Major Course

Pre-requisites: Modern Physics, Electronics-I

Objectives:

This course provides a foundation in condensed matter physics by developing an understanding of crystal structures, X-ray diffraction, lattice vibrations, thermal properties, and the free-electron theory of metals. It equips students with the analytical skills to explain the structural, thermal, and electrical properties of crystalline solids.

Course Learning Outcomes:

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

- 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.

Contents:

Crystal structure and x-ray diffraction: Introduction and scope of Condensed Matter Physics; Crystall Lattice, Basis and Translation vector; Symmetry operations; Bravais lattice; Crystal systems; Voids and Packing efficiency; Important Crystal structures (Sodium Chloride, Cesium Chloride, Diamond Cubic structure); Lattice Planes and Miller Indices; X-ray Diffraction (Bragg's Law and

Laue conditions for Diffraction); Experimental Methods in X-ray diffraction (Laue's method, Rotating crystal and Powder Method); Reciprocal Lattice and its Properties; Interatomic Forces and Crystal Binding.

Lattice vibrations and thermal properties of solids: Elastic waves, Vibrations of One-Dimensional Mono and Diatomic Lattices; Vibrational Modes of Three-Dimensional Lattice; Quantization of Elastic waves (Phonons); Specific Heat of Solids; Dulong Petit Law; Einstein's Model; Debye's Theory; Thermal conductivity; Phonon-Phonon Interaction (Normal and Umklapp Processes).

Free electron theory of metals: Outstanding features of Metals; Drude Model; D.C. Electrical conductivity; Thermal conductivity; Wiedemann-Franz Law, Hall Effect, A.C. Electrical conductivity; Sommerfeld Model: Energy Quantization of Electrons in Metals; Degeneracy of Energy States; Density of Energy States, Fermi-Dirac Statistics; Thermionic Emission and Electronic Specific Heat.

Recommended books:

1. Kittel, C. *Introduction to Solid State Physics*. Wiley, New York.
2. Ashcroft, N. W. and Mermin, N. D. *Solid State Physics*. Holt, Rinehart and Winston, New York.
3. Sidebottom, D. L. *Fundamentals of Condensed Matter and Crystalline Physics*. Cambridge University Press.
4. Omar, M. A. *Elementary Solid-State Physics*. Addison-Wesley.
5. Hofmann, P. *Solid State Physics: An Introduction*. Wiley.
6. Christman, J. R. *Fundamentals of Solid-State Physics*. Wiley, New York.
7. Dekker, A. J. *Solid State Physics*. Prentice Hall, Englewood Cliffs.

PHY-611 ATOMIC AND MOLECULAR PHYSICS Credit Hours: 3 (3-0)

Major course

Objective:

To provide an introduction to the structure and spectra of atoms and molecules. To prepare students for more advanced courses on Physics of Atoms, Molecules and Photons.

Course Learning Outcomes:

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

- 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.

Contents:

Introduction: Historical development of atomic models; Review of Bohr's Theory of Hydrogen and Hydrogen-Like Atoms: Finite Mass Correction; Correspondence Principle; Wilson-Sommerfeld Quantization Rules; Sommerfeld's Elliptical Orbits; Relativistic correction.

Vector Atom Model: The magnetic moment of an electron; Gyromagnetic Ratio; Bohr Magneton; Larmor's theorem; Space quantization and Electron spin; Quantum Numbers and their Physical Significance; Aufbau Principle; Pauli Exclusion Principle; Hund's rule; Electronic structure of atom.

Atomic Spectra and Fine Structure: LS and JJ Coupling; Selection rules; Lande Splitting Factor; Spectroscopic Terms; Stern-Gerlach Experiment; Fine Structure of Hydrogen Atom**.**

Atom in External Fields: Normal and Anomalous Zeeman Effect; Classical Theory of the Normal Zeeman Effect; Quantum Theory of Normal and Anomalous Zeeman Effect; Paschen-Back Effect; The Stark Effect.

Molecular Spectra: Introduction; Molecular Bonding; Diatomic Molecule as a Rigid Rotator; Rotational Energy Levels; Spectral Transition Probabilities and Selection Rules; Vibrational Spectra; Determination of Bond Length; Vibrational-Rotational Spectra; Electronic Spectra.

Lasers: Introduction; Absorption; Spontaneous and Stimulated Emission; Einstein's Coefficients; Laser Beam Characteristics; Population Inversion; Pumping Schemes (Electrical and Optical); Optical resonators/cavities; Type of Lasers (He-Ne Laser, Ruby laser, CO2 laser); Applications.

Experiments:

1. Planck Constant apparatus (essential)
2. Zeeman effect apparatus (desirable)
3. Quantum Hall apparatus (essential)
4. Electrons Spin resonance apparatus (essential)
5. Hydrogen discharge spectrum (desirable)
6. Sodium lamp (essential)
7. Polarization of light equipment / apparatus (essential)

Recommended books:

1. White, H. E. *Introduction to Atomic Spectra*. McGraw-Hill Book Company.
2. Bransden, B. H., and Joachain, C. J. *Physics of Atoms and Molecules* (2nd Edition). Pearson Education, 2003.
3. Eisberg, R., and Resnick, R. *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles* (2nd Edition). John Wiley & Sons, 1985.
4. Beiser, A. *Concepts of Modern Physics* (6th Edition). McGraw-Hill Education.
5. Thorne, A. P. *Spectrophysics* (2nd Edition). Chapman and Hall, 1988.
6. Ghatak, A., and Thyagarajan, K. *Lasers: Fundamentals and Applications* (2nd Edition). Springer, 2010.
7. B.B. Land 'Lasers and Nonlinear Optics' 2/e New Age International Publishers, New Delhi (2001).

PHY-614 QUANTUM MECHANICS -II Credit Hours: 3(3-0)

Major course

Pre- Requisites:

Objectives:

Course Learning Outcomes

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

- Solve advanced quantum mechanical problems involving angular momentum.
- Analyze the quantum behavior of multi-particle systems.
- Apply approximation methods of quantum mechanics to various problems.

The Schrodinger Equation in Three Dimensions

Separation of Schrödinger Equation in Cartesian Coordinates (The Free Particle, The Three-Dimensional Box) Central Potential and Separation of the Schrödinger Equation in Spherical Polar Coordinates; the Free Particle the Three-dimensional Square Well Potential: Analysis of Hydrogen-like Atoms; The Three-Dimensional Isotropic Oscillator.

Approximate Methods

Time Independent Perturbation Theory for Non-degenerate and Degenerate Energy Levels; the Variational Method; the WKB Approximation; Time Dependent Perturbation Theory.

Identical Particles and Second Quantization

Many particle system, System of identical particles, Pauli Exclusion Principle, The Exclusion principle and periodic table

Theory of Scattering

Scattering Experiments and Cross-sections; Potential Scattering, the Method of Partial Waves and its Application; the Born Approximation.

Recommended Books:

1. A.P.Frech and E.F Taylor‟ An Introduction to Quantum Physics' Thomas Nelson (1978)
2. J.L. Powel and B. Crasemann‟ Quantum Mechanics' Addison-Wesley. Reading(1978)
3. R.H. Dicke‟ Introduction to Quantum Mechanics' Addison-WealeyReading(1966)
4. P.M. Mathews and K. Venkatcsan‟ A Textbook of Quantum Mechanics' Tata Mic GrawHill(1976)
5. N. Zettili‟ Quantum Mechanics: Concepts and Application 2/e John Wiley (2009)

PHY-613 FIELD EXPERIENCE /INTERNSHIP Credit Hours: 3(0-3)

Major course

Objective: Field experience is a professional learning experience that offers meaningful and practical work experience related to a student's field of study or career interest. It is an opportunity to apply knowledge gained in the classroom with practice in the field.

PHY-615 NUCLEAR PHYSICS Credit Hours: 3(2-1)

Major course

Objectives: To understand the nuclear structure using different nuclear models. To understand the nature of nuclear forces. To give understanding of radioactivity and nuclear reactions.

Course Learning Outcomes:

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

- 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.

Contents:

History: starting from bacqurel's discovery of radioactivity to chedwick's neutron.

Basic properties of nucleus: Nuclear size; mass; binding energy; nuclear spin; magnetic dipole and electric quadruple moment parity and statistics.

Nuclear forces: Yukawa's theory of nuclear forces, charge independence and spin dependence of nuclear force.

Nuclear models: Introduction, liquid drop model, shell model, collective model,

Theories of radioactive decay:

(a) alpha decay: - Energy, range, ionization power and stopping power of alpha particles: quantum mechanical theory of alpha decay; alpha particle spectra, nuclear energy levels.

(b) beta decay:-Selection rules for beta decay, energy velocity and range of beta particles; fermi theory of beta decay; neutrino hypothesis, non-conservation of parity.

(c) gamma decay: Energy range and nature of gamma rays; theory of gamma decay; classification of gamma decays; internal conversion.

Nuclear reactions: Conservation laws of nuclear reactions; q-value and threshold energy of nuclear reaction; energy level and level width; cross section for nuclear reactions; bohr‟s theory of compound nucleus and its limitation; direct reaction; resonance reactions; breit-wigner one level formula.

Experiments:

1. To study the characteristics of Geiger-Muller tube and calculation of its dead time.
2. To investigate the characteristics of an ionization chamber.
3. To study the nature of radioactive decay i.e. Poisson distribution.
4. To determine the half-life a radioisotope (Radon-220)

5. Range of alpha particles in air using a solid- state detector.
6. Absorption coefficient of aluminum for beta particles.
7. Measurement of linear absorption coefficient of lead for gamma rays.
8. Verification of inverse square law for gamma rays.
9. Measurement of the gamma ray spectrum of a radioisotope.
10. Use of a multi – channel analyzer

Recommended Books:

1. E.Segre‟ Nuclei and Particles‟ Addison-Wesley (1977)
2. I. Kaplan‟ Nuclear Physics' Addison-Wesley (1962)
3. A.E.S. Green‟ Nuclear Physics' McGraw Hill (1955)
4. Kenneth S. Krane‟ Introductory to Nuclear Physics „john Willy (1987)
5. S.B. Patel „Nuclear Physics: An Introduction „New Age International (P) Ltd, New Delhi (1991)
6. S.N Ghoshal „Nuclear Physics' S. Chand and Co; New Delhi (1994)
7. W.E Burcham‟ Elements of Nuclear Physics' Longman (1979)

PHY-642 ARTIFICIAL INTELLIGENCE IN PHYSICS Credit Hours: 3(3-0)

Interdisciplinary course

Pre-Requisites: ICT

Objectives:

This course introduces Artificial Intelligence techniques for Physics applications, focusing on Python-based implementation of machine learning algorithms to model and predict physical systems. It integrates computational physics with data-driven methods. Prior knowledge of Python and computational Physics is required.

Course Learning Outcomes:

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

- 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.

Contents:

Introduction: What is Artificial Intelligence (AI) and why AI in Physics. Different types of Machine Learning (ML) models. Data Preprocessing: normalization, scaling, train-test split.

Supervised Learning: Introduction to Linear Models, Polynomial Regression, Regularized Linear Models, Logistic Regression, Gradient Descent and Optimization. Extracting resistance from Ohmic behavior, energy vs temperature data. Classification. Phase classification in Ising model simulations.

Model Evaluation and Selection: Performance Metrics: Accuracy, MSE, RMSE, R^2, Precision, Recall, F1-Score, Cross-Validation, Confusion Matrix, Bias-Variance Tradeoff, Receiver Operating Characteristic (ROC) Curves.

Support Vector Machines (SVM): Linear and Nonlinear SVM Classification, SVM, Regression. Identify critical temperature from simulation data, Materials classification (metal vs semiconductor and magnetic vs non-magnetic)

Decision Trees: Training and Visualizing a Decision Tree, Estimating Class Probabilities, The Classification and Regression Trees Training Algorithm, Regularization Hyperparameters, Random Forests and Feature Importance.

Unsupervised Learning: Clustering, K-Means, Using Clustering for Preprocessing, Gaussian Mixtures, Dimensionality Reduction, Principal Component Analysis (PCA), t- Distributed Stochastic Neighbor Embedding (t-SNE). Identify unknown phases from simulation.

Neural Networks and Deep Learning: Introduction to Artificial Neural Network, Logical Computations with Neurons, The Perceptron, Activation Functions, the Multilayer Perceptron (MLP) and Back propagation, Regression MLPs, Classification MLPs. Deep neural networks for regression and classification. Predicting formation energy, Grain boundary detection.

Reinforcement Learning: Introduction to Reinforcement Learning, Markov Decision Processes (MDPs), Q-Learning and Deep Q Networks (DQNs), Policy Gradients, Actor- Critic Method.

Physics-Informed Neural Networks (PINNs): Introduction to PINN, and solving differential equations with PINN. Modeling a falling ball's trajectory with PINN.

Recommended Textbooks:

1. AI For Physics, Volker Knecht (CRC Press Taylor & Francis 2022)
2. Deep Learning and Computational Physics, Deep Ray, Orazio Pinti, Assad A. Oberai, (Springer 2025)
3. Machine Learning for Physics and Astronomy, Viviana Acquaviva, (Princeton University Press 2023)
4. Physics-Informed Neural Network with Python an Introduction, G. R. Liu (Scien Tech Publisher 2025)

PHY-616 CAPSTONE PROJECT Credit Hours: 3(0-3)

Objective:

A capstone project allows students to bring together the concepts, principles and methods that they have learned in their course of study and to apply their knowledge and acquired competencies to address the real-world problems.

The research work will be conducted in 8th semester. In the final defense of project, a prototype will be shown to the external examiner and a project report will be submitted.

PHY-618 MECHATRONICS Credit Hours: 3(2-1)

Elective course

Objective:

This course provides a foundation in sensors, actuators, and digital control systems. It develops students' ability to interface sensors and actuators, program Arduino- and ESP32-based controllers, and design embedded control systems for measurement, automation, and motion control applications.

Contents:

Introduction: Introduction, DC motor speed controller, stepper motor speed and position controller, DC motor position and speed controller.

Sensors: Position and speed measurement (Proximity Sensors and Switches, Potentiometer, Linear Variable Differential Transformer, Digital Optical Encoder), stress and strain measurement (Electrical Resistance Strain Gage, Measuring Resistance Changes with a Wheatstone Bridge, Measuring Different States of Stress with Strain Gages, Force Measurement with Load Cells), temperature measurement (Liquid-in-Glass Thermometer, Bimetallic Strip, Electrical Resistance Thermometer, Thermocouple), vibration and acceleration measurement (Piezoelectric Accelerometer), pressure and flow measurement, semiconductor sensors and microelectromechanical devices.

Actuators: Electromagnetic principles, solenoids and relays, electric motors, dc motors, electronic control of a permanent magnet dc motor, stepper motors, stepper motor drive circuits, hydraulics (hydraulic valves, hydraulic actuators), pneumatics (pneumatics cylinder, pneumatics muscle and their control)

Digital Control: Arduino Uno, Arduino nano, Arduino mega, ESP32, Bluetooth module (HC-05/06), Introduction to scratch programing, introduction to mBlock, mBlock for programing Arduino

(Uno, Nano, Mega, and ESP32). Programing for sensors, Programing for motors (Stepper, Servo and DC).

Experiments:

1. Experiments on different types of Temperature sensors and signal conditioner.
2. Experiments on linear position sensor and conditioner
3. Experiments on angular position and speed measurement sensor
4. Experiments on Pressure sensors
5. Experiments on weight sensors
6. Experiments on water level and pressure
7. Experiments on stepper and DC motors
8. Experiments on vacuum level sensors and actuators
9. Experiments on industrial interface card using visual designer

Recommended Books:

1. David G. Alciatore and Michael B. Histand. "**Introduction to Mechatronics and Measurement Systems**", Fourth Edition, (Mc Graw Hill 2012)
2. Robert H. Bishop **"Mechatronics an introduction**" , First Edition, (Taylor & Francis 2006)

PHY-619 NANOSCIENCE AND NANOTECHNOLOGIES Credit Hours: 3(2-1)

Elective course

Pre-requisite: Solid State Physics-II, Quantum Mechanics-II

Objective(s):

This course provides a foundation in nanoscience and nanotechnology by introducing quantum effects, nanomaterials, nanoscale fabrication, characterization techniques, molecular electronics, and nanobiotechnology. It develops students' ability to understand, analyze, and apply nanoscale principles in advanced materials, electronic devices, and emerging technologies.

Contents:

Introduction: Feynman talks on small structures, Nano scale dimension, Course goals and objectives.

Quantum Effects: Wave particle duality, Energy quanta, Uncertainty principle, De Broglie relation, Quantum Dots, Moore's law, tunneling.

Surfaces and Interfaces: Interfaces, Surface chemistry and physics, Surface modification and characterization, Thin Films, Sputtering, Selfassembled films.

Material Properties: Subatomic physics to chemical systems, types of chemical bonds, solid state physics / Material properties.

Tools and Instrumentation: STM, AFM, Electron Microscopy, Fluorescence methods, Synchrotron Radiation.

Fabricating Nano Structures: Lithography (photo and electron beam), MBE, Self-assembled masked, FIB, Stamp technology, Nano junctions.

Electrons in Nano Structures: Variation in electronic properties, free electron model, Bloch's theorem, Band structure, Single electron transistor, Resonant tunneling.

Molecular Electronics: Lewis structures, Approach to calculate Molecular orbitals, Donor Acceptor properties, Electron transfer between molecules, Charge transport in weakly interacting molecular solids, Single molecule electronics.

Nano Materials: Quantum dots, nano wires, nano photonics, magnetic nano structures, nano thermal devices, Nano fluidic devices, biomimetic materials.

Nano Biotechnology: DNA micro-arrays, Protein and DNA Assembly, Digital cells, genetic circuits, DNA computing.

Nanotechnology the Road Ahead: Nanostructure innovation, Quantum Informatics, Energy solutions.

Experiments:

1. Experiments on Natural nanomaterials
2. Experiments on Liquid crystals
3. Experiments on Colorimetric gold nanosensor
4. Experiments on Superhydrophobic materials
5. Experiments on Electropolishing, Electroplating, Anodizing and Etching.

Recommended Books:

1. S. Lindsay, "Introduction to Nanoscience", Oxford University Press, 2009.
2. C. Binns, "Introduction to Nanoscience and Nanotechnology (Wiley Survival Guides in Engineering and Science)", Wiley, 2010.

PHY-620 CUMMUNICATION SYSTEM Credit Hours: 3(2-1)

Elective Course

Pre-requisites: Electronics-I and II

Objective:

This course provides a foundation in analog and digital communication systems by developing an understanding of signals and systems, modulation techniques, noise analysis, pulse and digital communications, and cellular communication technologies. It equips students with the analytical skills to evaluate, design, and analyze modern communication systems.

Contents:

Signals and Systems: Introduction to signals and systems; Types of signals; Types of systems; Signal representation; Review of Fourier series and transform. Fourier analysis of signals and systems

Modulation and Noise in Communication Systems: Modulation process and Modulation schemes; Analog and Digital types of Communication, baseband modulation and pass band modulation Noise in Communication Systems: Thermal noise; Calculation of Thermal Noise; Shot Noise; Signal to Noise Ratio; Noise Figure and Noise Temperature; Ideal Filter; Real Filter; Low-Pass, Band Pass, and High-Pass filters

Analogue Communications: Communication Model. Linear Modulation in Time Domain and Frequency Domain; Amplitude Modulation and its Mathematical Form; Demodulation of AM Wave; Carrier Suppression: DSBSC and SSBSC Generation and Demodulation of DSBSC and SSBSC Signals; VSB, Angle Modulation Frequency and Pulse Modulation; Generation of FM and PM Waves; Demodulation of FM and PM; Pre-Emphasis

Pulse and Digital Communications: Pulse Modulation (PAM,PTM,PWM And PPM); Digital Modulation Techniques (ASK, PSK, DPSK QPSK); Sampling Process; Shannon's Theorem; Analogue to Digital Conversion: Pulse Code Modulation ; Delta Modulation ; Adaptive Delta modulation; Signal detection; Inter Symbol Interference, Nyquist theorem, Error Detection and Error Correction (Hamming codes, Convolution codes);

Introduction to Cellular Communications: Introduction to Mobile communication; Evaluation of Mobile communications System cellular concept: Hand off Strategies; Interference and Channel Capacity; Cellular Phone Systems and Standards: Technical Features of AMPS and GSM; GSM System Architecture; GPRS; Multiple Access techniques; Frequency division Multiple Access(FDMA); Time Division Multiple Access (TDMA); Code Division Multiple Access (CDMA) ; Space Division Multiple Access (SDMA).

Experiments:

1. To design Amplitude Modulated circuit and calculate its modulation index.
2. To observe the demodulation of AM wave.
3. To construct a Frequency Modulated Circuit and to calculate the modulating index.
4. To observe the demodulation of FM wave.

5. Demodulation of FM using PLL circuit.
6. To construct a Balance Modulator circuit.
7. To construct a Pulse Amplitude Modulation and Demodulation circuit.
8. To study and implement PWM modulation using IC 555.
9. To construct a Pulse Position Modulation circuit.
10. To Study and implement ASK modulation and demodulation circuit.
11. To construct a FSK modulation and demodulation circuit.
12. To Study Pre Emphasis and De Emphasis circuit.
13. Experiment on Fourier analysis of Signals.
14. Experiments on Passive and Active Filters.

Recommended Books:

1. H. Taube and D.L. Schilling 'Principles of Communication Systems' 2/e McGraw-Hill (1986)
2. B.P Lathi' Modern Digital and Analog Communication Systems '3/e Oxford University (1998)
3. A.B Carlson' Communication Systems '4/e McGraw-Hill (2001)
4. S. Hay kin' Communication Systems '4/e John Wiley (2001)
5. W. Tomasi' Electronic Communication Systems: Fundamentals through Advanced '6/e Pearson Education (2005)
6. L.E Frenzel 'Principles of Electronic Communication Systems' 3/e, McGraw-Hill (2007)
7. G.Kennedy and B. Davis 'Electronic Communication Systems '4/e Glencoe (1993)
8. R. Stele and L. Hanzo (Eds.)' Mobile Radio Communications' 2/e John Wiley (1999)

PHY-621 CONDENSED MATTER PHYSICS-II Credit Hours: 3(3-0)

Elective course

Pre-requisite: Condensed Matter Physics-I

Objective:

This course provides a foundation in the electronic, dielectric, magnetic, and superconducting properties of solids. It develops students' ability to analyze band theory, semiconductor behavior, polarization and magnetization phenomena, and the principles and applications of superconductivity.

Contents:

The band theory of solids: Introduction; The Bloch Theorem; The Kronig-Penny Model; Analysis and Existence of Energy Bands; The Distinction among Metals, Insulators and Semiconductors; Brillouin Zones and Reduced Zone Scheme; Effective Mass of Electron;

Semiconductors: Introduction; Band Structure and Types of Semiconductors; Carrier Concentration in Intrinsic Semiconductors; Product of Electron and Hole Concentration; Position of Fermi Level; Carrier Concentration in Extrinsic Semiconductors; Temperature Dependence of Carrier Concentration; Hall Effect in Semiconductors; Cyclotron Resonance.

Dielectric and magnetic properties: Macroscopic description of Electric Polarization in Solids; Electric Susceptibility and Dielectric constant; Polarizability; Sources of Polarizability (electronic, ionic and orientational); The Local Field; Dielectric in an Alternating Field; Dielectric Loss; Origin of Magnetism; Atomic Magnetic moment; Magnetic Permeability and Susceptibility; Magnetization; Classification of Magnetic materials (Dia, Para and ferromagnetism); Domain Theory and Magnetic Hysteresis; Antiferromagnetic materials and Ferrimagnetic materials.

Superconductors: Basic Concept of Superconductivity; Critical Temperature, Field and Current; Meissner Effect; Type I and Type II Superconductors; Theoretical aspect: The BCS theory; Flux Quantization and Josephson Effect; High Temperature Superconductors; Applications of Superconductors.

Recommended books

1. Kittel, C. *Introduction to Solid State Physics*. Wiley, New York.
2. Ashcroft, N. W. and Mermin, N. D. *Solid State Physics*. Holt, Rinehart and Winston, New York.
3. Sidebottom, D. L. *Fundamentals of Condensed Matter and Crystalline Physics*. Cambridge University Press.
4. Omar, M. A. *Elementary Solid-State Physics*. Addison-Wesley.
5. Hofmann, P. *Solid State Physics: An Introduction*. Wiley.
6. Christman, J. R. *Fundamentals of Solid-State Physics*. Wiley, New York.
7. Dekker, A. J. *Solid State Physics*. Prentice Hall, Englewood Cliffs.
8. Streetman, B. G. and Banerjee, S. *Solid State Electronic Devices*. Pearson Education.

PHY-622 PLASMA PHYSICS Credit hours: 3(3-0)

Elective course

Pre-requisite: Electromagnetic Theory-II, Waves and Oscillations

Objective:

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

Contents:

Introduction: Occurrence of plasma, Concept of temperature, Debye shielding, the plasma parameter, Criteria for plasma.

Applications of Plasma Physics: Single-particle motion in electromagnetic field, Uniform and non-uniform E and B fields, Time-variant E and B fields, Fluid description of plasma, Wave propagation in plasma, Derivation of dispersion relations for simple electrostatic and electromagnetic modes, Introduction to Controlled Fusion, Basic nuclear fusion reactions, Reaction rates and power density, radiation losses from plasma, operational conditions.

Recommended Books:

1. F. F. Chen, "Introduction to Plasma Physics", 2nd ed. Plenum, 1995.
2. D. A. Gurnett and A. Bhattacharjee, "Introduction to Plasma Physics: with space and laboratory application", Cambridge University Press, 2005.
3. T. J. M. Boyd and J. J. Sanderson, "The Physics of Plasmas", Cambridge University Press, 2003.

PHY-623 QUANTUM FIELD THEORY Credit hours: 3(3-0)

Elective course

Pre-requisites: Quantum Mechanics-II

Objective:

This course provides a foundation in quantum field theory by developing an understanding of field quantization, relativistic quantum fields, gauge invariance, and particle interactions. It equips students with the analytical skills to formulate, analyze, and apply quantum field theoretical methods to elementary particle interactions using Feynman diagrams and quantum electrodynamics (QED).

Contents:

Lagrangian Field Theory: Classical Field Theory. Canonical Quantization. Noether's theorem. **Klein-Gordon Field:** Real Klein-Gordon field. Complex Klein-Gordon field. Covariant commutation relations. Meson propagator

Dirac Field: Number representation for fermions. Quantization of Dirac field. Spin-statistics theorem. Fermion propagator

Electromagnetic Field: Classical electromagnetic field. Covariant quantization. Photon propagator

Interacting Fields: Interaction Lagrangian and gauge invariance. Interaction picture. S-matrix expansion. Wick's theorem. Feynman Diagrams. Feynman rules for QED. Cross sections and decay rates.

Recommended Books:

1. F. Mandl and G. Shaw, "Quantum Field Theory", Wiley, 2nd ed. 2010.
2. M. E. Peskin and D. V. Schroeder, "An Introduction to Quantum Field Theory", Addison Wesley, 1995.
3. S. Weinberg, "The Quantum Theory of Fields", Vol. 1, Cambridge University Press, 1999.
4. N. N. Bogoliubov and D. V. Shirkov, "Introduction to the Theory of Quantized Fields", John Wiley, 1980.

PHY-624 FLUID DYNAMICS Credit hours: 3(3-0)

Elective course

Pre-requisites: Mechanics, Calculus-I, Differential Equations

Objective(s): Physical understanding of fluid dynamics.

Contents:

Introduction: Phenomenological introduction to fluid dynamics, Kinematics and conservation laws, Ideal fluids, the Euler equations, irrational flow, The Navier-Stokes equations

Viscous flow: Stokes flow, drag, lubrication theory, thin film flow

Waves: surface waves, internal gravity waves, nonlinear waves.

solitons, shocks Instabilities: linear stability analysis, Kelvin-Helmholts instability, Rayleigh-Bénard convection, other instabilities

Other topics depending on interest and as time permits possibly: airfoil theory, granular flows, biophysical flows.

Recommended Books:

1. D. J. Acheson, "Elementary Fluid Dynamics", Oxford University Press, 1990.
2. P. K. Kundu and I.M. Cohen, "Fluid Mechanics", Academic Press, 4th ed. 2010.
3. D. J. Tritton, "Physical Fluid Dynamics", Clarendon, 2nd ed. 1988.
4. L. D. Landau and E. M. Lifschitz, "Fluid Mechanics", Butterworth- Heinemann, 2nd ed. 1

PHY-625 INTRODUCTION TO MATERIALS SCIENCE Credit hours: 3(3-0)

Elective course

Pre-requisites: Solid State Physics-I

Objective(s): To understand the important aspects of materials. Moving towards microstructures.

Content:

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.

Imperfections in Solids: Vacancies, impurities, dislocations, interfacial defects, bulk or volume defects, atomic vibrations.

Microstructure: Microstructure and microscopy, pressure vs. temperature phase diagrams, temperature vs. composition phase diagrams, equilibrium, thermodynamic functions, variation of Gibbs energy with temperature and composition, general features of equilibrium phase diagrams, solidification, diffusion mechanisms, nucleation of a new phase, phase diagrams of Fe-C system and other important alloys, materials fabrication.

Mechanical Behavior of Materials: Normal stress and normal strain, shear stress and shear strain, elastic deformation, plastic deformation, Young's modulus, shear modulus, Poisson's ratio, elastic strain energy, thermal expansion, estimate of the yield stress, dislocations and motion of dislocations, slip systems, dislocations and strengthening mechanisms, fracture mechanics, ductile fracture, brittle

fracture, Griffith criterion, ductile fracture, toughness of engineering materials, the ductile-brittle transition temperature, cyclic stresses and fatigue, creep.

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 Tg, effect of temperature and time, mechanical properties of polymers, case studies in polymer selection and processing.

Biomaterials: Introduction to biomaterials, materials selection, biopolymers, structural polysaccharides, hard materials, biomedical materials.

Recommended Books:

1. W. D. Callister, "Materials Science and Engineering: An Introduction", Wiley, 7th ed. 2006.
2. W. D. Callister and D. G. Rethwisch "Fundamentals of Materials Science and Engineering: An Integrated Approach", Wiley, 4th ed. 2012.
3. J. F. Shackelford, "Introduction to Materials Science for Engineers", Prentice Hall, 7th ed. 2008.

PHY-626 PARTICLE PHYSICS Credit hours: 3(3-0)

Elective course

Pre-requisites: Quantum Mechanics-II, Nuclear Physics

Objective:

This course provides a foundation in elementary particle physics by developing an understanding of fundamental particles, their interactions, relativistic kinematics, quantum electrodynamics, gauge field theories, and particle symmetries. It equips students with the analytical skills to interpret particle interactions and explore the theoretical foundations of the Standard Model and modern particle physics

Contents:

Introduction to Elementary Particles: Fundamental building blocks and their interactions. Quantum Electrodynamics. Quantum Chromodynamics. Weak interactions. Decays and conservation laws.

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

Quantum Electrodynamics: Klein-Gordon equation. Dirac equation. Solution of Dirac equation. Bilinear covariants. Feynman rules for QED. Casimir's trick. Cross sections & lifetimes. Neutrino Oscillations: Solar neutrino problem. Oscillations, Neutrino masses. PMNS mixing matrix.

Gauge Field Theories: Lagrangian in Relativistic Field Theory. Gauge Invariance. Yang-Mills Theory. The mass term. Spontaneous symmetry breaking. Higgs mechanism. Higgs boson. Grand Unification. Supersymmetry. Extra dimensions. String theory. Dark energy. Dark Matter.

Recommended Books:

1. D. Griffiths, "Introduction to Elementary Particles", Wiley-VCH, 2nd ed. 2008.
2. F. Halzen and A.D. Martin, "Quarks and Leptons: An introductory course in modern Particle Physics", John Wiley, 1984.
3. D. H. Perkins, "Introduction to High-Energy Physics", Cambridge University Press, 4th ed. 2000.
4. V. D. Barger and R. J. N. Phillips, "Collider Physics", Addison-Wesley, 1996.

PHY-627 INTRODUCTION TO RENEWABLE ENERGY Credit Hours: 3(3-0)
Elective Course

Pre-requisites: Nil

Objective:

Students are introduced to different types of renewable energy resources by engaging in various activities to help them understand the transformation of energy (solar, water, nuclear, biomass and wind) into electricity. Students explore the different roles engineers who work in renewable energy fields have in creating a sustainable environment – an environment that contributes to greater health, happiness and safety.

Content:

Introduction: Promising renewable energy sources, their potential availability and present status, existing technologies and availability,

Solar energy: Sun-Earth relationship, solar geometry, sun path and solar irradiance, solar spectrum. Solar constant, atmospheric effects, global distribution, effects of tilt angle, daily and seasonal variations, resource estimation. Extraterrestrial, global, direct, diffused radiation, Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency,

Photovoltaic: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power spectral response, fill factor, temperature effect; PV systems, components, modules, arrays, controllers, inverters, storage, PV system sizing, performance and applications,

Wind Energy: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect.,

Hydropower: Global resources, and their assessment, classification, micro, mini, small and large sources principles of energy conversion; turbines, their working and efficiency for micro to small power systems, environmental impact,

Biogas: Biomass sources; residue, farms, forest. Solid wastes; agricultural, industrial and municipal wastes etc.; applications, traditional and nontraditional uses: utilization, process, gasification, digester, types, energy forming, Environment issues,

Geothermal Energy: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects,

Nuclear Energy: Global generations of reserves through reprocessing and breeder reactors, growth rate prospect of nuclear fusion, safety and hazards issue.

Experiments:

1. Measurement of power of Solar cell
2. Measurement of Color effect on absorption of solar radiation
3. Study the plate flat collectors
4. Study of different parameter of solar cooker.
5. Wind speed and direction measurement.

Recommended Books:

1. Manfred Grathwhol. World Energy Supply: Resources, Technologies and Prospective, Walter deGruyter-Berlin, Latest edition
2. J.W Twidell and A.D. Weir. Resources, E & F.N. Spon Ltd, London, Latest edition
3. M Iqbal. An Introduction to Solar Radiation, Academic Press, Canada, Latest edition
4. Simon Roberts. A Practical Guide to Solar Electricity, Prentice Hall, Latest edition
5. Martin A G. Solar cells: Operating Principles, Technology, & System Application, Prentice Hall, Latest edition

PHY-628 WIND ENERGY Credit Hours: 3(2-1)

Elective Course

Objective:

To study about properties and statistical analysis of the wind, wind generators, wind energy conversions and economics of wind energy.

Contents:

Introduction, Properties and Statistical Analysis of the Wind, Wind Generators History, Wind Shear, Roughness Classes and Turbine Energy Production, Fluid Mechanics, Euler and Bernoulli Equations, Aerodynamics of Rotor Blades, Energy and Power Content of the Wind, Wind Energy Conversion Theory, Betz Equation, Torque Generation in Wind Turbines, Optimal Rotor Tip Speed Ratio, Components of Wind Machines Orography and Wind Turbine Siting, Offshore Wind Farms Siting, Airborne Wind Turbine Concepts. Vertical Axis Wind Turbines, Small Wind Generators, Modern Wind Generators, Wind Turbines in the Urban Environment, Dynamic and Structural Loading in Wind Turbines, Fatigue Loading in Wind Turbines, Wind Energy Converters Concepts, Control of Wind Turbines, Computational Fluid Dynamics, Random Numbers Generation, Economics of Wind Energy, Energy Storage with Wind Power Functioning of a hydropower system; classification of the typologies of hydropower systems and main components. Classification of hydropower plants. Reversible hydropower plant. Classification based on the size of the system.

Practicals:

Demonstration of different parts of Wind Turbine, performance evaluation and Energy measurement of a wind turbine, determination of wind tip speed for different sized wind turbines, calculation of transformation of a wind turbine, visit of wind power plant for mechanical and electrical energy, Application of Bernoulli's principle in the laboratory, Demonstration of impulse and reaction turbines model, power calculation from hydel turbine, Visit to Hydel power plant.

Books recommended:

1. Du, P. and N. Lu. Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources (VERs), Academic Press, USA, Latest edition
2. Moore, T.R. and E.I. Bailey. Wind Power: Systems Engineering Applications and Design Models, Nova Science Publishers Inc, UK, Latest edition
3. Wagner, H.J. and M. Jyotirmay. Introduction to Hydro Energy Systems, Springer-Verlag Berlin Heidelberg, Latest edition

PHY-629 HYDRO POWER SYSTEMS Credit Hours: 3(3-0)

Elective Course

Objective:

To introduce the students with hydropower system,

Contents:

Introduction to hydropower system, Hydro power plant, Selection of Site, Classification of hydropower plants, classification of the typologies of hydropower systems and main components. Classification based on the size of the system, Reversible hydropower plant, Classification layout governing of turbines, Hydrologic (water) cycle, global hydro power, and hydro resource assessment, The Operating principles and the characteristics of selected turbines, Criteria for selection of a particular turbine, Concepts of gross head, net head, energy line, hydraulic grade line and available head, Conversion of hydro- power to electrical power: Shaft torque and shaft power. Plant - Equipment and performance, Performance enhancement techniques, equipment, Energy storage: pumped storage facilities. Economic analysis and environmental considerations,

Books recommended:

1. Du, P. and N. Lu. Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources (VERs). Academic Press, USA, Latest edition
2. Wagner, H.J. and M. Jyotirmay. Introduction to Hydro Energy Systems, Springer-Verlag Berlin Heidelberg, Latest edition
3. Godfrey Boyle. Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K., Latest edition
4. Khartchenko .N.V. Advanced Energy Systems, Taylor and Francis, Washington DC, Latest edition
5. Chauhan. D.S, Srivastava .S.K. Non-Conventional Energy Resources, New Age, Latest edition
6. Georgiadis M.C. Energy Systems Engineering, Wiley-VCH, Latest edition
7. Twidell, J. W. and Weir, A. D. Renewable Energy Resources, Taylor and Francis, Latest edition
8. Alexandrou, A. Principles of Fluid Mechanics, Prentice-Hall, Inc. Latest edition
9. Sørensen, B. Renewable Energy, New York Academic Press, Latest edition
10. John Twidell and Tony Weir. Renewable energy resources, Taylor and francis, Latest edition

PHY-630 TIDAL AND GEOTHERMAL ENERGY Credit Hours: 3(3-0)

Elective Course

Objective:

To study the tidal and geothermal energy, tidal and wave energy conversion. A case study related to geothermal energy is also included.

Contents:

Geothermal Energy: Geology of Geothermal Regions, Exploration Strategies and Techniques Principles, heat source systems for ambient air utilization, heat source systems for shallow geothermal utilization, Geothermal well drilling, design of down hole part, up hole part, district heating system, environmental analysis of geothermal energy. Case study related to geothermal energy, Single and double Flash Steam Power Plants, Binary Cycle Power Plants, Advanced Geothermal Energy Conversion Systems, Energy Analysis Applied to Geothermal Power Systems: Tidal and Wave energy, Tidal and Wave Energy Conversion Systems, well

Books recommended:

1. Pimental, D. and R. DiPippo. Geothermal Power Plants, Elsevier. USA, Latest edition
2. Gupta, H. and S. Roy. Geothermal Energy – An Alternative Resource for the 21st Century, Elsevier, USA, Latest edition
3. Tabak, J. Solar and Geothermal Energy, Facts On File, Latest edition
4. Charlier, R.H. and W.Finkl. Ocean Energy Tide and Tidal Power. Springer, Latest edition
5. Brooke, J. Wave Energy Conversion, Elsevier Ocean Engineering Series Latest edition

PHY-631 SOLAR ENERGY Credit Hours: 3(3-0)

Elective Course

Objective:

To learn the fundamentals of solar energy conversion systems, available solar energy and the local and national needs, solar engineering applications, emerging technologies. Students will be able to serve industries or academia involved in sustainable energy engineering.

Contents:

Solar energy: Solar insulation vs. world energy demand, current energy consumption from different sources, environmental and health effects. Sustainable Energy: Production and storage, resources and utilization. Fundamentals of solar cells: Types of solar cells, semiconducting materials, band gap theory, absorption of photons, excitons and photoemission of electrons, band engineering. Solar cell properties and design: p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron and holes transports, device physics, charge carrier generation,

recombination and other losses, I-V characteristics, output power; Single junction and triple-junction solar panels, metal-semiconductor hetero junctions, and semiconducting materials for solar cells. Low, medium and high temperature collectors, types of solar energy collectors; Heat storage, storage media, steam accumulator, other storage systems, heat exchangers and applications of stored energy. Thermoelectricity, Peltier effect, Seebeck effect; Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radioisotope thermoelectric generator; Thermoelectric power generators, thermoelectric refrigerators and heat pumps.

Books recommended:

1. Green, M.A. Solar Cells: Operating Principles, Technology and system Applications, Kensington, N.S.W. University of New South Wales, Latest edition
2. Goswami, D.Y. Principles of Solar Engineering, Taylor and Francis, USA, Latest edition
3. Wenham, S.R., M.A. Green., M.E. Watt. And R. Corkish. Applied Photovoltaics, Earthscan, USA, Latest edition
4. Lasnier, F. and T.G. Ang. Photovoltaic Engineering Handbook, Adam Hilger. IOP Publishing Ltd, Bristol. USA, Latest edition
5. Sze, S.M. Semiconductor Devices, Physics, and Technology, John Wiley & Sons, New York. USA, Latest edition

PHY-632 Hydrogen and Fuel Cells Credit Hours: 3(3-0)

Elective Course

Objective:

To study about the fuel-cell technology, introducing Hydrogen as a future energy carrier, students will be able to understand the usage of Hydrogen in internal combustion engines.

Contents:

Fuel-cell technologies, possible fuels, and their applications solid oxide fuel cells (SOFCs), Hydrogen as Future Energy Carrier. Introduction: Hydrogen Fuel Cell Engines and Technologies, Hydrogen Properties, thermal, electrolytic, Photolytic processes of hydrogen decomposition. Hydrocarbon Decomposition water decomposition. Hydrogen Distribution, Hydrogen Storage, Hydrogen Use in Internal Combustion Engines: Hydrogen feeding system, air feeding system, thermal management system, Integrated Fuel Cell System. Hydrogen feedstock and basics of its reforming, Fuel Cell Principles: Introduction to fuel-cell types, basic principles; Fuel cell thermodynamics; Fuel cell reaction kinetics; Charge transfer in fuel cells; Mass transport in fuel cells; Fuel cell characterization. Overview of fuel cell types; Proton exchange membrane and solid oxide fuel cell materials. Overview of fuel cell systems.

Books recommended:

1. Corbo, P., F. Migliardini, and O. Veneri. Hydrogen Fuel Cells for Road Vehicles, Springer-Verlag London Limited, Latest edition
2. Stolten, D. and B. Emonts. Fuel Cell Science and Engineering, Wiley-VCH Verlag & Co. KGaA, Weinheim. Germany, Latest edition, Vol I
3. O'Hayre, R.P., S.W. Cha., W. Colella and F.B. Prinz. Fuel Cell Fundamentals, John Wiley & Sons, New York. USA, Latest edition
4. Bejan, A. Advanced Engineering Thermodynamics, John Wiley & Sons, USA, Latest edition
5. Hoogers G. Fuel Cell Technology Handbook, CRC Press and SAE International USA, Latest edition
6. Larminie J. and A. Dicks. Fuel cell systems explained, John Wiley and Sons, England, Latest edition
7. Li, X. Principles of Fuel Cells, Taylor & Francis Group, New York. USA, Latest edition
8. Blomen, L.J.M.J. and M.N. Mugerwa. Fuel Cell Systems, Plenum Press, New York. USA, Latest edition

PHY-633 ENERGY STORAGE Credit Hours: 3(3-0)

Elective Course

Objective:

To study about different energy storage systems including different types capacitors, batteries, advance batteries and to study some areas of applications of energy storage.

Contents:

Energy Storage Systems, Need of energy storage, Different modes of Energy Storage. Potential energy: Pumped hydro storage, Kinetic energy and Compressed gas system: Flywheel storage, compressed air energy storage, Electrical and magnetic energy storage: Capacitors, electromagnets, Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage, Electrochemical Energy Storage Systems: Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead Lead, acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes, Superconducting Magnet Energy Storage (SMES) systems, Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube. Sensible Heat Storage, SHS mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings; Earth storage; Latent Heat Thermal Energy Storage, Phase Change Materials (PCMs); Selection criteria of PCMs, Some Areas of Application of Energy Storage: Food preservation; Waste heat recovery; Solar energy storage; Greenhouse heating; Power plant applications, Drying and heating for process industries, Energy Storage -Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds.

Books recommended:

1. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider. Principles of Solar Engineering, Taylor & Francis, Indian reprint, Latest edition
2. Edward E. Anderson. Fundamentals for solar energy conversion. Addison Wesley Publ. Latest edition
3. Duffie J. A and Beckman, W .A. Solar Engineering of Thermal Process, John Wiley, Latest edition
4. G. N. Tiwari and M. K. Ghosal. Fundamentals of Renewable energy Sources, Narosa Publishing House, New Delhi, Latest edition
5. W. Shepherd and D. W. Shepherd. Energy Studies, Imperial College Press, London, Latest edition

PHY-634 PHOTOVOLTAIC Credit Hours: 3(3-0)

Elective Course

Objective:

To learn about solar photovoltaic system components, types, design and performance measurement.

Contents:

An introduction to Photovoltaics, the physics behind the technology, the devices and practical applications, Photovoltaic cells, Basic PV operation, PV technologies, semiconductor physics, solar cell structures, their principle of operation, design and fabrication. Photovoltaic systems including power converters and energy storage, residential grid-connected photovoltaic systems. Solar PV system components, types and characteristics, Solar cells type, characteristics and configurations, solar charge controllers, types, characteristics, solar inverters type and characteristics', Solar cables, solar mounting system, solar PV system types; Solar PV off grid, hybrid and on grid systems. Solar photovoltaic applications, solar system performance measurement and monitoring, solar system operation and maintenance.

Books recommended:

1. Duffie, J.A. and W.A. Beckman. Solar Thermal Engineering, Wiley and Sons. USA, Latest edition
2. Kreith, F. and J.F. Kreider. Principles of Solar Engineering, McGraw-Hill, New York, Latest edition
3. Kalodirou, S.A. Solar Energy Engineering: Processes and Systems, Latest edition
4. Wenham, S.R., M.A. Green., M.E. Watt. And R. Corkish. Applied Photovoltaics, Earthscan, USA, Latest edition
5. Green, M.A. Solar Cells: Operating Principles, Technology and System Applications., University of New South wales, Latest edition
6. Lorenzo, E., G. Araujo. And A. Cuevas. Solar Electricity: Engineering of Photovoltaic Systems, Earthscans Publications Ltd. Latest edition

PHY-635 MICROBIAL BIOENERGY AND BIOFUEL Credit Hours: 3(3-0)

Elective Course

Objective:

After completing the course, the students will be able to Familiarize with different types of microbes associated with bioenergy, Understand role of microbes in producing Bioenergy and Biofuel, Lab. scale production of bioenergy and biofuel using conventional digester.

Contents:

Types of biomass (e.g. wood waste, forestry residues, agricultural residues, organic municipal solid waste). Types of microbial fuels (Biodiesel, Bioethanol, Biomethane/Biogas, Biohydrogen etc,), Phenomena for production of Biofuel (bioenergy and biofuel etc.), role of microbes (aerobic and anaerobic) in biofuel production and isolation and characterization of different aerobic and anaerobic. Isolation and characterization of biofuel producing bacteria (Biodiesel; E.coli, Microalgae, Biomethane; Methanogenic archae (Biohydrogen, Cyanobacteria, Clostridia, Bioalgae, Botryococcus bruanici, PNS Bacteria. Bioethanol (Lactobacillus casei, saccharomyces cerevisiae, Zymomonas morbilis, klebsiella oxytoca, E.coli, Clostridium cellulyticum, Preparation and studies of Consortium of microbes useful in Bioenergy/Biofuel. Microbial fuel cell.

Books recommended:

1. Packiasamy, R. Seasonal Distribution of Methanogens in Manimuthar River, Lap lambert Academic Publishing, Latest edition
2. Bhojvaid, P.P. Biofuels: Towards a Greener and Secure Energy Future. The Energy and Resources Institute, India, Latest edition
3. Arora, R. Microbial Biotechnology: Energy and Environment, CABI India, Khanal, S. Anaerobic Biotechnology for Bioenergy, Latest edition

PHY-636 CAD AND 3D PRINTING Credit Hours: 3(1-2)

Elective course

Objective: This course introduces students to the principles of Computer-Aided Design (CAD), 3D modelling, additive manufacturing technologies, and practical applications of 3D printing. Students will learn to create digital models, prepare designs for fabrication, operate 3D printers, and evaluate printed components.

Course Learning Outcomes:

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

- Understand fundamentals of CAD and digital manufacturing.
- Develop 3D models using CAD software.
- Apply design principles for additive manufacturing.

- Operate and troubleshoot basic 3D printing systems.
- Select suitable materials and printing parameters for applications.
- Evaluate the quality and performance of 3D printed objects.

Contents:

1. Introduction to CAD and Digital Design
- History and applications of CAD
- CAD systems and software environment
- Engineering drawing standards

2. 3D CAD Modeling
- Solid modelling concepts
- Extrusion, revolution, loft and sweep features
- Assembly design and editing
- Product visualization and rendering

3. 3D simulation

Simulation of 3D parts for load, elastic limit, deformation, and fluid flow

4. Introduction to 3D Printing
- Principles of additive manufacturing
- Types of 3D printing technologies
- FDM, SLA, SLS and other techniques

5. Design for 3D Printing
- STL and other file formats
- Slicing software and print preparation
- Layer thickness, infill and support structures

Recommended Textbooks:

1. Engineering Design Graphics with Autodesk Inventor by James D. Bethune,, Pearson.
2. Mastering Autodesk Fusion by Autodesk
3. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer
4. 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific
5. Design for Additive Manufacturing, Elsevier
6. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley

PHY-637 **COSMOLOGY** **Credit hours: 3(3-0)**

Elective course

Pre-requisite: Nil

Objective:

The course introduces the fundamental concepts of modern cosmology. The meaning of time and space in an expanding universe are discussed, and the dynamics of the expansion, starting from a hot Big Bang. Observational evidence includes the abundance of light elements, the microwave background, and large-scale structure.

Course Learning Outcomes:

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

- Apply knowledge of core concepts in physics and astrophysics to understand cosmology.
- Formulate solutions to problems in cosmology involving new concepts with limited guidance.

- Demonstrate knowledge of the frontiers of the discipline, for example, through cases where current theories fail to explain a set of observational data.
- Locate and make use of detailed information on current topics in cosmology in the primary research literature.
- Summarise current thinking in cosmology in a variety of written and oral forms, both alone and in collaboration with others.

Contents:

1. History and Basic Concepts: Historical development of cosmology; Cosmological principle; Homogeneity and isotropy; Newtonian and relativistic cosmology; Expansion of the Universe; Hubble's law; Fundamental cosmological parameters (H_0, Ω, Λ).

2. The Robertson–Walker Metric: Space-time geometry; Curved space; Scale factor; Robertson–Walker line element; Spatial curvature (open, flat, closed universes); Comoving and proper coordinates; Geodesics in expanding space.

3. Light Propagation and Redshifts: Cosmological redshift; Doppler vs. cosmological redshift; Photon propagation in expanding space-time; Null geodesics; Luminosity and angular diameter distances; Horizon concepts.

4. Dynamics of the Universe Einstein field equations; Friedmann equations; Critical density; Density parameters; Matter-, radiation-, and vacuum-dominated universes; Evolution of the scale factor; Age of the Universe.

5. Observational Cosmology: Distances and Ages in the Universe Distance measurements; Look-back time; Cosmic time; Standard candles and standard rulers; Distance-redshift relation; Age determination methods.

6. The Distance Ladder: Parallax method; Cepheid variable stars; RR Lyrae stars; Tully–Fisher relation; Surface brightness fluctuations; Type Ia supernovae; Calibration of cosmic distances.

7. Thermal History of the Universe: Freeze-out Early Universe thermodynamics; Thermal equilibrium; Particle interactions; Decoupling processes; Freeze-out mechanism; Relic particle abundances; Entropy conservation.

8. Primordial Nucleosynthesis: Big Bang nucleosynthesis (BBN); Formation of light elements; Neutron-proton ratio; Nuclear reaction network; Predicted elemental abundances; Observational evidence; Constraints on cosmological parameters.

9. Recombination and the Microwave Background: Recombination epoch; Photon decoupling; Formation of neutral atoms; Cosmic Microwave Background (CMB); Blackbody spectrum; Temperature anisotropies; Acoustic peaks; Polarization of the CMB.

10. Dark Matter: Observational Evidence and Candidates Galaxy rotation curves; Galaxy clusters; Gravitational lensing; Bullet Cluster; Large-scale structure; Baryonic vs. non-baryonic dark matter; WIMPs; Axions; Neutrinos; Detection methods.

11. Formation of Structure: Growth of density perturbations; Jeans instability; Linear perturbation theory; Dark matter halos; Galaxy formation; Large-scale structure; Numerical simulations; Cosmic web.

12. Problems with the Big Bang: Inflation, Accelerated Expansion, and Dark Energy Horizon problem; Flatness problem; Monopole problem; Inflationary theory; Inflation models; Quantum fluctuations; Evidence for accelerated expansion; Cosmological constant; Dark energy models; Equation of state parameter.

13. Status and Future Observations: Precision cosmology; Current cosmological model (ΛCDM); Hubble tension; CMB experiments; Galaxy redshift surveys; Gravitational wave cosmology; 21-cm cosmology; Future space missions and ground-based observatories.

Recommended textbooks:

1. **Barbara Ryden** – *Introduction to Cosmology*

2. **Andrew Liddle** – *An Introduction to Modern Cosmology*
3. **Edward Kolb & Michael Turner** – *The Early Universe*
4. **Scott Dodelson** – *Modern Cosmology*
5. **Steven Weinberg** – *Cosmology*

PHY-638 INTRODUCTION TO QUANTUM COMPUTING Credit hours: 3(3-0)

Elective course

Pre-requisite: Quantum Mechanics-I, Computational Physics

Objective(s):

To be familiar with the quantum computing. To learn about the Quantum circuits, and cryptography. Computer technology and historical background, Basic principles and postulates of quantum mechanics: Quantum states, evolution, quantum measurement, superposition, quantization from bits to qubits, operator function, density matrix, Schrodinger equation, Schmidt decomposition, EPR and Bell's inequality, Quantum Computation: Quantum Circuits, Single qubit operation, Controlled operations, Measurement, Universal quantum gates, Single qubit and CNOT gates, Breaking unbreakable codes: Code making, Trapdoor function, One time pad, RSA cryptography, Code breaking on classical and quantum computers, Schor's algorithm, Quantum Cryptography: Uncertainty principle, Polarization and Spin basis, BB84, BB90, and Ekert protocols, Quantum cryptography with and without eavesdropping, Experimental realization, Quantum Search Algorithm.

Recommended Books:

1. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Foundation Books, 2007.
2. P. Williams and S. H. Clearwater, "Exploration in Quantum Computation" Springer, 2011.
3. P. Bouwmester, A. Ekert, and A. Zeilinger, "The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation", Springer, 2010.
4. R. K. Brylinsky and G. Chen, "Mathematics of Quantum Computation" by Chapman & Hall/CRC, 2002.

COURSES OF ARTS AND HUMANITIES

Only one course of Arts and Humanities from the below list will be taken depend upon the availability of faculty member.

S. No	Course Code	Course Title	Cr. Hrs.
1	HIS-501	Introduction to History	2 (2-0)
2	PHIL-501	Introduction to Philosophy	2 (2-0)
3	MS-501	Introduction to Mass Communication	2 (2-0)
4	PSY-501	Introduction to Psychology	2 (2-0)

HIS-501 **INTRODUCTION TO HISTORY** **Credit hours: 2(2-0)**

Arts and Humanities course

Content:

What is History? Nature and scope of History. Benefits of History: History as a corrective force; History as a repetitive force, Branches of History (political, cultural, social, economic), Relationship of History with other social sciences, Causation, Objectivity and subjectivity, Classification of History: Narrative History, Scientific History, Philosophy of History, Future History

Recommended Books:

1. Bernard Cohn. An Anthropologist among Historians and Other Essay, Oxford University Press, 1988
2. Caroline Steedman. Dust: The Archive and Cultural History, Manchester University Press, 2002
3. Carlo, Ginzburg. Clues. Myths, and the Historical Method, John Hopkins: University Press, 1992
4. Carr, E. H., What is History? Harmondsworth: Penguin, 1961.
5. Collingwood, R. G. The Idea of History. Oxford: Oxford University Press, 1978.
6. G. W. G. Hegel. Elements of the Philosophy of Right. Cambridge University Press, 1991
7. Gertrude Himmalfarb. The New History and the Old, Cambridge: Harvard University Press, 1987
8. Govranski. History Meaning and Methods, USA, 1969
9. John Struart Mill. On Liberty and Other Essay, Oxford University Press, 2008

PHIL-501 **INTRODUCTION TO PHILOSOPHY** **Credit hours: 2(2-0)**

Arts and Humanities course

Contents:

Introduction to Philosophy: Definition of Philosophy, Etymology of Philosophy, Scope of Philosophy, Nature of Philosophy.

Philosophical Questions *(Note: Learning Method: Question/Answer Method):* What Is Truth? What is Justice? What is Good? What is Beauty? What is Love? What Is the Meaning of Life? Is Knowledge Possible? What Does It Mean to Be Free? Are You Really You? How Does the Brain Produce the Mind? Does Happiness Define the Good? What Makes a Society Fair or Just?

Branches of Philosophy: Metaphysics, Epistemology, Logic, Ethics, Political Philosophy, Aesthetics.

Historical Background of Philosophy: Ancient Greek Philosophy, Medieval Western and Muslim Philosophy, Modern Western Philosophy.

Philosophy and Social Sciences: Philosophy and Psychology, Philosophy and Sociology, Philosophy and Political Science, Philosophy and Literature

Recommended books

1. Dr. Khalid Almas and KashifFaraz Ahmed "Advanced Philosophy "Advanced AP Pub. Lahore.
2. W. Russ Payne, "An Introduction to Philosophy" Bellevue College, 2015.
3. Edward Craig, "Philosophy A Very Short Introduction" by Oxford University Press, Inc., New York 2002.
4. Dallas M. Roark, Ph.D. "Introduction to Philosophy" Emporia State University Copyright 1982 edition, 2016.
5. Nigel Warburton "Philosophy: The Basic" published byRoutledge, fifth edition published 2013.
6. Oswald kulpe "Introduction to philosophy, translated from the German (1895), W. B. Pillsbury and E. B Titchener, London Swan Sonnenschein. & Co., Limited New York:

MS-501 INTRODUCTION TO MASS COMMUNICATION Credit hours: 2(2-0)

Arts and Humanities course

Contents:

Definition, types and significance of communication, Process of Communication: source; message; channel; noise; destination; encoding; decoding; and feedback. Barriers in communication.

• Essentials of effective communication

• Dimensions of mass communication: mass media, advertising, public relations, blogging, new media etc.

• **Nature and Functions of mass communication:** (Information, Education, opinion Formation, Entertainment and Development)

• Introduction to journalism, Definition, assignment, and pursuit of a "beat," key writing concepts, including the inverted pyramid, how to write a lead, and when and how to use quotes effectively.

• In addition to covering basic news stories, students will be exposed to various magazine styles, and encouraged to write a query letter and feature article for a magazine of his or her choice.

• The art and practice of good reporting skills, which includes brainstorming story ideas, rudimentary interviewing skills, and contacting sources in preparation for a series of news stories (crime/accident/fire/town meeting)

Recommended books

1. Dominick J.R. (2006). *Dynamics of MassCommunication.*(8th edition). New York McGrawHill
2. Merrill, J.C Le, Friedlander, E.J (1994). *Modern Mass Media*(2ndedition).New York. Harper Collin College Publishers
3. Straubhaar, La Rose. (2002). *Media Now: Communication Media in theInformation Age* (3rdEdition.) USA, Wadswort

PSY-501 INTRODUCTION TO PSYCHOLOGY Credit hours: 2(2-0)

Arts and Humanities course

Contents:

Understanding Psychology

Psychology: Scientific perspective, Historical perspective, Schools of psychology, Methods of psychology, Fields of psychology and their application

Biological Basis of Behavior

Neuron and its function, Nervous system: Central and Peripheral, Endocrine system

Sensation and Perception

Sensation and the Senses: Vision, audition, smell, taste and kinesthetic
Perception: Principles of perceptual organization
Depth Perception: Binocular and monocular cues
Illusions and extra sensory perception
Learning: Definition of learning, Types of learning: Classical and Operant conditioning; Social learning
Memory: Definition and types of memory, Processes and techniques of improving memory
Forgetting: Nature and causes
Cognition and Intelligence: Concept of cognition, Problem solving, Judgment and decision making, LanguageDevelopment, Concept and Theories of intelligence, Assessment of intelligence, Concept ofcreativity and its stages
Motivation and Emotion: Concept and types of motivation, Factors affecting motivation, Introduction to emotions,Theories of emotions, Physiology and emotion
Personality: Defining personality, Theories of personality, Personality assessment
Social Influence and Socialization
Social facilitation, Crowd behavior, Conformity, Obedience, Helping behavior, Agents of Socialization

Recommended Books

1. Atkinson R. C., & Smith, E. E. (2000). Introduction to psychology (13th ed.). NY: Harcourt Brace College Publishers.
2. Coon, D., & Mutterer, J. (2008). Introduction to psychology: Gateways to mind and behavior (12thed.). USA: Wadsworth Cengage Learning.
3. Fernald, L. D., & Fernald, P.S (2005) Introduction to psychology. USA; WMC Brown Publishers.
4. Fredrickson, B., Nolen-Hoeksema, S., Loftus, G., &Wagenaar, W.(2009). Atkinson & Hilgard'sIntroduction to psychology (15th ed.). USA: Wadsworth.
5. Glassman, W.E. (2000). Approaches to psychology. Open University Press.
6. Hayes, N. (2000). Foundation of psychology (3rd ed.). UK: Thomson Learning.
7. Kalat, J. W. (2010). Introduction to psychology USA. Cengage Learning, Inc.
8. Lahey, B. B. (2004). Psychology: An introduction (8th ed.). UK: McGraw-Hill Companies,
9. Inc.
10. Myers, D. G. (2011).Psychology (10th ed.). USA: Wadsworth Publishers.
11. Ormord, J. E. (1995). Educational psychology: Developing learners. USA: Prentice Hall, Inc.
12. Rathus, S. (2011). Psychology: Concepts and connections (10th ed.). USA: Wadsworth CengageLearning.

COURSES OF SOCIAL SCIENCE

Only one course of Social Science from the below list will be taken depend upon the availability of faculty member.

S. No	Course Code	Course Title	Cr. Hrs.
1	GEOG-501	Fundamentals of Geography	3(3-0)
2	DMDS-501	Fundamental of Disaster Management	3(3-0)
3	IR-501	Introduction to International Relations	3(3-0)
4	SOC-501	Introduction to Sociology	3(3-0)
5	POLSC-501	Introduction to Political Science	3(3-0)
6	ECO-501	Fundamentals of Economics	3(3-0)

GEOG-501 FUNDAMENTALS OF GEOGRAPHY Credit hours: 2(2-0)

Social Science course

Contents:

1. **Introduction:** Nature and scope, the evolution of geography from ancient to modern times, branches of Geography and their relations with other disciplines
2. **Five Major Themes of Geography**: Location: Absolute and relative, Place: Physical and anthropogenic characteristics, Man-environment relationship, Movement, Region
3. **Earth as a planet:** Shape, size and movements, Earth's Satellite-Moon, Lunar and Solar Eclipses
4. **Location on Map and Globe:** Directions and scales, Geographical coordinates and their characteristics, World time zones: standard and local time
5. **Distribution of Land and Water:** Proportion of land and water on the planet earth, Fresh water; glaciers, rivers, lakes, swamps and underground water, Ocean water
6. **Elements of Geo-system**: Lithosphere, Atmosphere o Hydrosphere, Biosphere

Recommended Books

1. Strahlar, A.N., Strahlar, A.H. Physical Environment, John Wiley. New York (2004).
2. Stringer, E.T. "Modern Physical Geography," New York: John Wiley (2004).
3. Christopherson, R.W. "Geo-systems," Prentice-Hall, Inc, USA (2000).
4. Gabler, R.E, Sager, R.J and Wise, D.L. "Essentials of Physical Geography", Saunders College Publishing, New York (1997)
5. Thurman, H.V. &Mexrill "Essentials of Oceanography", Menson, London (1996).
6. Fraser,C. "Unlocking Five Themes of Geography", Globe Book Co. New Jersey (1993).
7. Taylor, J. "Integral Physical Geography", Longman, London (1993).
8. Mcliveen, J.F.R. "Fundamentals of Weather and Climate," Prentice Hall (1992).
9. Thompson, R.D. et al. "Process in Physical Geography", London, Longman (1986).

DMDS-501 FUNDAMENTAL OF DISASTER MANAGEMENT Credit hours: 2(2-0)

Social Science course

Contents:

1. **Introduction to Disaster Management:** Basics Concepts evolving terminologies in Disaster Management, Nature and Scope of Disaster Management, Historical Evolution
2. **Classification of Disasters:** Socio-Natural Disasters, Anthropogenic Disasters, Technological Disasters
3. **Concept of Risk, Vulnerability and Capacity:** Disaster Risk, Vulnerability (Types and Causes, Models), Capacity and Types of Capacity**,** Level of Capacities
4. **Disaster Risks Trends:** Global Disaster Risk Trends, Costs and Frequency, Historical Review of Disasters Trends
5. **Case Studies on Impacts of Disasters:** Economic, Social, Environmental, Physical Infrastructure

Recommended Books:

1. Comprehensive Risk Assessment for Natural Hazards. World Meteorological Organization 2006.
2. DAMON, P. C. (2006) International Disaster Management. Butterworth-Heinemann.
3. UNISDR. (2009). Global Assessment Report on Disaster Risk Reduction, United Nations International Strategy for Disaster Reduction.
4. Wisner, B., P. Blaikie, T. Cannon, and I. Davis. (2004). "At Risk: Natural Hazards, People's Vulnerability and Disasters (2nd Ed.)." Rutledge, London, UK.
5. W. N. Carter (1999) Disaster Management: Disaster Manager's Handbook, Manila: Asian Development Bank.

IR-501 INTRODUCTION TO INTERNATIONAL RELATIONS Credit hours: 2(2-0)

Social Science course

Contents:

Meaning, Definition, Nature, and Scope of International Relations, Evolution and Development of International Relations, Significance of International Relations, Concept of Nation State, International System and Sub-Systems, Foreign Policy, National Interest, and Diplomacy, Power and Balance of Power, Regionalism and Globalization**,** State and Non-State Actors, Human Rights in International Relations**,** Religion, Ethics, Morality and Justice in International Relations, The Role of Economics in International Relations**,** The Concept of War and Peace in International Relations

Recommended Books:

1. Columbus, Theodore. Introduction to International Relations: Power and Justice. New Delhi: Prentice Hall, 1992.
2. Goldstine, Josha. International Relation. Washington DC: Pearson Education, 2003 3. Lawson, Stephanie. International Relations; Cambridge; Polity, 2003.
3. Amstutz, Mark R. International Conflict and Cooperation: An Introduction to World Politics. (Chicago: Brown & Benchmark, 1995)
4. Griffiths, Martin, and Callaghan, Terry O'. International Relations: The Key Concepts. London, Routledge, 2003.
5. Henderson, Conway W. International Relations: Conflict & Cooperation at the Turn of the 21stCentury Boston: McGraw-Hill, 1998.
6. Jackson, Robert and Sorensen; Georg, Introduction to International Relations Theories and Approaches, Oxford: Oxford University Press, 2003.
7. Jackson, Robert and Dorreen Jackson. A Comparative Introduction to Political Science. New Jersey: Prentice – Hall, 1997.

SOC 501 INTRODUCTION TO SOCIOLOGY Credit hours: 2(2-0)

Social Science course

Contents:

1. Introduction: Definition, Scope, and Subject Matter, Sociology as a Science, Historical back ground of Sociology, Relationship of sociology with other social sciences
2. Basic Concepts: Group, Community, Society; Associations: Non-Voluntary, Voluntary; Organization: Informal, Formal; Social Interaction, Levels of Social Interaction, Process of Social Interaction: Cooperation, Competition, Conflict, Accommodation, Acculturation and diffusion, Assimilation, Amalgamation
3. Social Groups: Definition and Functions; Types of social groups: In and out groups, Primary and Secondary group, Reference groups, Informal and Formal groups, Pressure groups
4. Culture: Definition, aspects and characteristics of Culture, Material and non-material culture, Ideal and real culture
5. Elements of culture: Beliefs, Values, Norms and social sanctions
6. Organizations of culture: Traits, Complexes, Patterns, Ethos, Theme
7. Other related concepts: Cultural Relativism, Sub Cultures, Ethnocentrism and Xeno centrism, Cultural lag
8. Socialization and Personality: Personality, Factors in Personality Formation, Socialization, Agencies of Socialization, Role and Status
9. Deviance and Social Control: Deviance and its types, Social control and its need, Forms of Social control, Methods and Agencies of Social control
10. Collective Behaviour: Collective behaviour, its types, Crowd behavior, Public opinion, Propaganda, Social movements, Leadership

Recommended Books:

1. Anderson, Margaret and Howard F. Taylor. 2001. *Sociology the Essentials*. Australia: Wadsworth.
2. Brown, Ken 2004. *Sociology*. UK: Polity Press
3. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition *Sociology* New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. *Introduction to Sociology* 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. *International Encyclopedia of Sociology*. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. *Sociology* 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. *Sociology: Social Structure and Social Conflict.* New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. *Sociology: An Introduction to the Science of Society*. New York: Barnes and Nobel.
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. *Marriage and The family.*New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. *Order and Change: Introductory Sociology* Toronto: Oxford University Press.

POLSC-501 INTRODUCTION TO POLITICAL SCIENCE Credit hours: 2(2-0)
Social Science course

Contents:

1. Defining Social Sciences and differentiating it from natural and physical sciences
2. Defining Political Science, its history, method and subject matter.
3. Relationship of Political Science with other social sciences.
4. Major Fields of Political Science: Political Philosophy, Political Theory, Political Economy, Comparative Politics, International Relations
5. State: Its origin, evolution and types
6. Government: Legislature, Executive, Judiciary.
7. Sovereignty
8. Regime Types: Authoritarianism and Democracy
9. Forms of Democratic Governments: Presidential and Parliamentary forms.
10. Basic concepts of Political Science: Power, Authority, Legitimacy

Recommended Books:

1. Ellen Grigsby (2016) *Analysing Politics: An Introduction to Political Science,* Oxford University Press, London.
2. Ian Mackenzi (Ed.), Political Concepts: A Reader and Guide, Edinburgh, University Press, 2005.
3. Robert Jackson and Dorreen Jackson, A Comparative Introduction to Political Science, New Jersey, Prentice – Hall, 1997
4. V. D. Mahajan, Political Theory- Principles of Pol. Science, New Delhi, S. Chand & Co., 2006.

ECO-501 FUNDAMENTALS OF ECONOMICS Credit hours: 2(2-0)
Social Science course

Contents:

Basic Economic concepts: Nature and functions of every economic system. Nature and scope of economic analysis. Economic terms. The major segments of economic theory. Micro-economics and macro-economics. Micro-economic (Price Theory): The price of market mechanism. The influence of the price system on resource allocation, consumption patterns and income distribution. Determination of price by supply and demand. The assumption of perfect competition. The theory of demand and utility. Elasticity of demand and its measurement. The theory of cost and supply. Equilibrium of the firm Equilibrium of demand and supply in the short-run and long-term periods. Pricing of the productive factors. Wages, profits, interest and rent. Macro-economic (income and Employment Theory): Measurement of national income. Concept of GNP, and NNP. Circular flow of national income. Three approaches to national income measurement, income at factor cost, income at market price and expenditure approach. Determination of the national income and employment. Equilibrium level of national income, saving, consumption and investment schedules and their inter-section. Say's law of markets and its refutation by "Keynes" general theory of employment-aggregate demand, aggregate supply, effective demand. Consumption function: The propensity of consume. The multiplier and its calculation. Logical identity of saving and investment. Investment as determinant of effective demand: Determinants of investment. The marginal efficiency of capital. The accelerator and its interaction with the multipliers. The rate of interest and investment. Economics, Statistics and Mathematics:

Economic Planning in Pakistan: Economic Development through Planning: The concept of measurement of economic development. The imperfections of market economy. The need and objectives of economic Planning. Special features of Pakistan's economy: Primary production in population pressure, capital deficiency, Low income. Development Planning in Pakistan:

Recommended Books:

1. Samuelson, P.A. (1961). *Economics*. McGraw-Hill Compant, New York.
2. Stonier, A.H. and Huage, D.C: A Text- Book of Economic Theory (Longmans, London, 1964).
3. Adrus, J.R. and Mohammad, A.F: Trade, Finance and Development in Pakistan, (Karachi 1966).
4. Meenal, S.A: Money and Banking in Pakistan (Karachi, 1966).
5. Qureshi, Al (ed.): The Third Five Year Plans and other Papers (Rawalpindi, 1966).
6. Mahbub-ul-Haq: The Strategy of Economic Planning A Case Study of Pakistan. (Karachi, Oxford University Press, 1963).
7. Govt. of Pakistan: First, Second and Third Five-Year Plans of Pakistan Report of the Food and Agriculture Commission (Karachi, 1960).
8. Pakistan Economic Survey for the years 1963-64, 1964-65 and 1965-66.
9. Pakistan Budgets for the years 1964-65, 1965-66 and 1966-67.