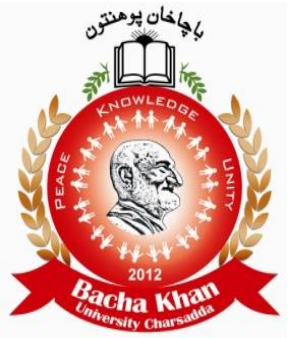
DEPARTMENT OF PHYSICS
BACHA KHAN UNIVERSITY CHARSADDA
REVISED CURRICULUM FOR BS/AD IN PHYSICS

Effective For BS/AD Physics Program for the Student Admitted in Fall 2025 Semester and Onwards in the Department of Physics Bacha Khan University Charsadda, and Affiliated Colleges

Approved by:

3rd Board of Studies of Department of Physics,
12th Board of Faculty of Sciences,
15th Academic Council of BKUC
and
Final approval by 36th Syndicate of BKUC.



DEPARTMENT OF PHYSICS
BACHA KHAN UNIVERSITY
CHARSADDA, PAKISTAN
2025

Table of Contents

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Preface

The curriculum is a crucial tool for students to achieve their academic and professional goals, integrating prior learning requirements, program objectives, scheme of studies, and course learning outcomes. As the field of Physics continues to advance and intersect with emerging disciplines, it is essential to periodically review and update the curriculum to keep pace with global developments.

The Department of Physics at Bacha Khan University, Charsadda, has designed the BS Physics curriculum in line with the guidelines and standards prescribed by the Higher Education Commission (HEC) of Pakistan and the Higher Education Department (HED), Government of Khyber Pakhtunkhwa, while incorporating the specific vision and mission of the University. This curriculum emphasizes both theoretical understanding and practical applications, ensuring that students are well-prepared to meet contemporary scientific, technological, and industrial challenges.

Our program aims to equip graduates with strong analytical skills, research capabilities, and innovative thinking, enabling them to contribute effectively to the advancement of Physics and its applications in areas such as lasers, materials science, medical physics, computational physics, and environmental studies. The curriculum also aligns with national priorities and international benchmarks, preparing students to engage meaningfully in scientific inquiry, technological innovation, and societal development at both the national and global levels.

With the University's commitment to quality education and research, we envision our Physics graduates playing a leading role in scientific discovery and technological progress, upholding the values of excellence, integrity, and service to humanity.

Dr. Amina
Head/Assistant Professor
Department of Physics
Bacha Khan University Charsadda

Guiding Principles

MINIMUM STANDARDS

The curricular standards and guidelines prescribed by the HEC are mandatory at minimum level. University or the department may however set higher standards provided that the standards prescribed by HEC are not reduced or compromised.

COURSE SEQUENCE, TITLES & CREDITS

The sequence of courses prescribed by HEC is logically arranged and is suggestive only. The department may rearrange the sequence and alter the course titles and credit hours provided that the essence of the courses prescribed remains intact. The department may also add more courses as and when required subject to approval of university's relevant statutory body. Courses at the 3XX level correspond to the first year of the BS program, and so on for subsequent years.

COURSE LEARNING OUTCOMES

The course learning outcomes (CLOs) prescribed by HEC represent the minimum level of competency and understanding expected from students. While these standards must not be compromised, departments are encouraged to enhance the rigor of the CLOs by incorporating additional learning outcomes, provided these do not alter the essence of the prescribed standards. The CLOs are exclusively developed for major and interdisciplinary courses, whereas for electives, CLOs are not prescribed as these are advanced or specialized courses. The development of CLOs for electives is the responsibility of the department, taking into account the course's advanced nature and relevance to the program. For General Education courses as prescribed in the HEC Undergraduate Education Policy V 1.1 including the course of Pakistan Studies, departments may adopt the CLOs prescribed in the HEC-developed model courses.

GENERAL EDUCATION

The courses prescribed for General Education including the course of "Pakistan Studies" must mandatorily be offered with the same titles and credit hours as prescribed in the HEC Undergraduate Education Policy V 1.1. The department may adopt and follow the learning outcomes and study contents developed by HEC for these courses.

Head
Department of Physics
Bacha Khan University
Charsadda

REQUIREMENT OF INTERNSHIP

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Physics. Internship of 6 to 8 weeks (preferably undertaken during semester or summer break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

REQUIREMENT OF CAPSTONE

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Physics. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

ASSOCIATE DEGREE IN PHYSICS

The eligibility criteria and the first-four semesters of the Bachelor of Science in Physics as prescribed in this document guide the admission requirement and the structure of Associate Degree in Physics, respectively. Field experience / internship is not a mandatory requirement for the Associate Degree in Physics.

LABORATORY REQUIREMENTS

The departments offering degree programs in Physics are required to adhere to the laboratory requirements as specified by HEC, as minimum standards. The department is expected to enhance the laboratory standards as and when required and maintain / upgrade the same from time to time in order to ensure quality education and research in the field of Physics.

ENTRY & EXIT PROVISIONS

Pathway for Graduates with Associate Degree:

a) Students having completed Associate Degree in Physics or any discipline related to the field of Physics shall be required to complete deficiency courses up-to a maximum of 18 credit hours (if required) as determined by the university. In case where the deficiency courses are of more than 18 credit hours, the university may decide not to offer admission in accordance with its screening, admission and merit calculation criteria approved by the university statutory bodies.

b) The minimum eligibility for admission in the fifth semester in this case is 2.00/4.00 CGPA obtained in the prior qualification i.e., Associate Degree.

Pathway for Graduates with Conventional BSc / Equivalent Degree Programs:

a) Students having completed two-year conventional BSc / equivalent degree programs are allowed admission in the fifth semester of Bachelor of Science in Physics in which case, such students shall be required to complete deficiency courses up-to a maximum of 21 credit hours as determined by the university. In case where the deficiency courses are of more than 21 credit hours, the university may decide not to offer admission in accordance with its screening, admission and merit calculation criteria approved by statutory bodies.

b) The minimum eligibility for admission in the fifth semester in this case is 45% cumulative score obtained in the prior qualification i.e., two-year conventional BSc / equivalent degree programs.

Exiting from Bachelor of Science in Physics with the Associate Degree:

Exit from Bachelor of Science in Physics with Associate Degree in the same discipline is allowed in accordance with the provisions of HEC Undergraduate Education Policy V 1.1 and only in such circumstances where no other remedy is available to safeguard the academic career of the student.

Head
Department of Physics
Bacha Khan University
Charsadda

PROGRAM DESCRIPTION

The Bachelor of Science in Physics program is designed in accordance with the HEC Undergraduate Education Policy V 1.1, the HED, Government of Khyber Pakhtunkhwa, and vision and mission of the University, offering students a comprehensive education in Physics, with an emphasis on both theoretical understanding and practical applications. The program spans eight semesters and provides a balanced curriculum that begins with general education courses, ensuring a strong foundation in mathematics, natural sciences, and critical thinking. As students progress, they will study specialized courses that cover key areas of Physics, including classical mechanics, quantum mechanics, electrodynamics, and thermodynamics, as well as emerging fields such as materials science. Throughout the program, students will engage in hands-on laboratory work, enhancing their technical skills and enabling them to apply theoretical concepts to real-world situations. While designing this program, emphasis is placed on the development of analytical and problem-solving abilities, with the aim of preparing students for careers in industry, education, and technology sectors.

STANDARD NOMENCLATURE

To ensure uniformity, the standard nomenclature of four-year undergraduate degree programs in Physics is “Bachelor of Science in Physics”.

PROGRAM LEARNING OUTCOMES

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

a) Demonstrate a comprehensive understanding of basic concepts related to core subjects in physics, including but not limited to classical mechanics, quantum mechanics, electromagnetism, statistical mechanics and thermodynamics.

b) Effectively apply mathematical and computational techniques to analyze and solve complex physical problems in both theoretical and experimental contexts.

Head
Department of Physics
Bacha Khan University
Charsadda

c) Communicate scientific knowledge and research findings effectively, demonstrating a commitment to continuous learning and professional development in the field of Physics.

ELIGIBILITY & ADMISSION CRITERIA

1. Higher Secondary School Certificate (involving 12 years of schooling) or an IBCC equivalent qualification with subjects of Physics with minimum 45% marks from any recognized Institute/College excluding Hafiz-e-Quran, or any other marks specified shall be eligible for admission to BS Physics.

2. Seats distribution will be as per university policy and will be changed as per university requirements.

PROGRAM STRUCTURE

The Bachelor of Science in Physics is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1 and comprises of minimum 134 credit hours spread over 8 regular semesters.

DEGREE AWARD REQUIREMENTS

The following minimum requirements are prescribed for the award of Bachelor of Science in Physics:

1. All courses in the General Education category with titles and credit hours as prescribed in the HEC Undergraduate Education Policy V 1.1 including the course of “Pakistan Studies” must be completed.

2. Minimum of 134 credit hours as prescribed in this document must be completed.

3. Capstone of 3 credit hours must be completed in accordance with HEC Undergraduate Education Policy V 1.1. This requirement cannot be substituted with additional coursework or internship.

4. Internship of 3 credit hours must be completed in accordance with HEC Undergraduate Education Policy V 1.1. This requirement cannot be substituted with additional coursework, capstone, research or project work.

5. CGPA must not be below 2.00/4.00 at the time of completion of the degree program.

6. The minimum duration to complete the degree program is 8 regular semesters and the maximum duration is 12 regular semesters. The maximum duration may further be extended in accordance with HEC semester guidelines and the university policy in vogue (updated from time to time).

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Charsadda

Minimum Credit Hours	134
General Education (Table-1)	32 credit hours (13 courses)
Discipline Related Courses / Major (Table-2)	78 credit hours (26 courses)
Interdisciplinary / Allied Courses (Table-3)	18 credit hours (6 courses)
Internship	3 credit hours
Capstone Project	3 credit hours
Program Duration	Minimum: 4 years (8 regular semesters) Maximum: 6 years (12 regular semesters) The maximum limit is further extendable in accordance with HEC semester rules and university policy in vogue (updated from time to time).
Semester Duration	16-18 weeks for regular semesters (1-2 weeks for examination)
Course Load (per semester)	15-18 credit hours for regular semesters (for remedial/deficiency/failure/repetition courses only)
3 Credit Hours (Theory)	3 classes (1 hour each) OR 2 classes (1.5 hour each) OR 1 class (3 hours) per week throughout the semester
1 Credit Hours (Lab / Field Work)	1 credit hour in laboratory or practical work / project requires lab contact of 3 hours per week throughout the semester

Head
Department of Physics
Bacha Khan University
Charsadda

TABLE-1 GENERAL EDUCATION COURSES

S. No.	Course Title	Credit Hours
1.	Quantitative Reasoning – I	3 (3-0)
2.	Natural Science	3 (2-1)
3.	Functional English	3 (3-0)
4.	Applications of Information & Communication Technologies (ICT)	3 (2-1)
5.	Quantitative Reasoning – I I	3 (3-0)
6.	Expository Writing	3 (3-0)
7.	Pakistan Studies	2 (2-0)
8.	Social Sciences	2 (2-0)
9.	Islamic Studies (Ethics for non-Muslim students)	2 (2-0)
10.	Arts & Humanities	2 (2-0)
11.	Ideology & Constitution of Pakistan	2 (2-0)
12.	Civics & Community Engagement	2 (2-0)
13.	Entrepreneurship	2 (2-0)
TOTAL CREDIT HOURS		32

TABLE-2 DISCIPLINE RELATED COURSES / MAJOR COURSES

S. No.	Course Title	Credit Hours
1.	Introductory Mechanics	3 (2-1)
2.	Waves & Optics	3 (2-1)
3.	Electricity & Magnetism	3 (2-1)
4.	Heat & Thermodynamics	3 (2-1)
5.	Differential Equations	3 (3-0)
6.	Modern Physics	3 (2-1)
7.	Vector Calculus	3 (3-0)
8.	Classical Mechanics	3 (3-0)
9.	Electronics – I	3 (2-1)
10.	Mathematical Methods of Physics – I	3 (3-0)
11.	Electromagnetic Theory	3 (3-0)

Head
Department of Physics
Bacha Khan University
Charsadda

12.	Electronics – II	3 (2-1)
13.	Quantum Mechanics – I	3 (3-0)
14.	Mathematical Methods of Physics – II	3 (3-0)
15.	Electrodynamics & Special Relativity	3 (3-0)
16.	Condensed Matter Physics	3 (3-0)
17.	Atomic & Molecular Physics	3 (2-1)
18.	Quantum Mechanics – II	3 (3-0)
19.	Nuclear Physics	3 (2-1)
20.	Elective – I	3
21.	Elective – II	3
22.	Statistical Mechanics	3 (3-0)
23.	Elective – III	3
24.	Elective – IV	3
25.	Artificial Intelligence in Physics	3 (2-1)
26.	Capstone	3
TOTAL CREDIT HOURS		78

TABLE-3 INTERDISCIPLINARY/ALLIED COURSES

S. No.	Course Title	Credit Hours
1.	Linear Algebra	3 (3-0)
2.	Environmental Physics	3 (3-0)
3.	Medical Physics	3 (3-0)
4.	Computational Physics	3 (2-1)
5.	Scientific Inquiry & Research Methods	3 (3-0)
6.	Artificial Intelligence in Physics	3 (2-1)
TOTAL CREDIT HOURS		**18**

Head
Department of Physics
Bacha Khan University
Charsadda

TABLE-4 ELECTIVE COURSES

Any advanced course in the field of Physics as an elective, where required as per the available academic, human and infrastructural resources. Credit combination (reflecting balance of theory and lab / field work) must be arranged in accordance with the nature of the course.

S. No.	Course Code	Course Title	Credit Hours
1.	PHY-623	Fluid Mechanics	3
2.	PHY-624	Introduction to Plasma Physics	3
3.	PHY-625	Methods of Experimental Physics	3
4.	PHY-626	Introduction to Quantum Computing	3
5.	PHY-627	Quantum Information	3
6.	PHY-628	Quantum Optics	3
7.	PHY-629	Quantum Field Theory	3
8.	PHY-630	Digital Electronics	3
9.	PHY-631	Introduction to Laser Physics	3
10.	PHY-632	Laser Applications	3
11.	PHY-633	Experimental Techniques in Particle and Nuclear Physics	3
12.	PHY-634	Electronic Materials and Devices	3
13.	PHY-635	Introduction to Photonics	3
14.	PHY-636	Introduction to Material Science	3
15.	PHY-637	Introduction to Nano Science & Nanotechnologies	3
16.	PHY-638	Particle Physics	3
17.	PHY-639	Computer Simulations in Physics	3
18.	PHY-640	Surface Physics	3
19.	PHY-641	Renewable Sources of Energy	3

Head
Department of Physics
Bacha Khan University
Charsadda

20.	PHY-642	Materials Characterization Techniques	3
21.	PHY-643	Introduction to Scintillation Materials	3
22.	PHY-644	Radiation Physics	3

TABLE-5 INTERNSHIP

Internship				
S. No.	Course Code	Course	Credit Hours	Category
1.	PHY-698	Internship	3	Field work like teaching, experimental skills or other practical learning related to physics
Note: Internship will be of 6 to 8 weeks (preferably undertaken during semester or summer break) must be graded by a faculty member in collaboration with the supervisor in the field. So it means that the contact hours will be from 18 to 24 hours				

TABLE-6 NATURAL SCIENCES

Any course in the broader category of "Natural Sciences" which should have relevance to the purpose of the degree program such as Mathematics, Statistics, Chemistry, Geology, Geophysics or Computer Science (or any other approved Basic Course of BKUC).

S. No.	Course Code	Course Title	Credit Hours
1.	GEOL-311	Fundamental of Geology	3 (2-1)
2.	BOT-311	Botany (Diversity of Plants-I)	3 (2-1)
3.	ZOO-311	Zoology (Animals Diversity-I)	3 (2-1)
4.	CHEM-310	Chemistry-I	3 (2-1)

Head
Department of Physics
Bacha Khan University
Charsadda

TABLE-7 SOCIAL SCIENCE

S. No.	Course Code	Course Title	Credit Hours
1.	IR-311	Introduction to International Relations	2 (2-0)
2.	POL-314	Introduction to Political Science	2 (2-0)
3.	SOC-314	Introduction to Sociology	2 (2-0)
4.	PSY-311	Fundamental to Psychology	2 (2-0)
5.	EC-310	Introduction to Economics	2 (2-0)
6.	LAW-411	Introduction to Law	2 (2-0)

TABLE-8 ARTS AND HUMANITIES

S. No.	Course Code	Course Title	Credit Hours
1.	PASH-324	Pashto Language*	2 (2-0)
2.	URD-323	Urdu Language*	2 (2-0)
3.	IS-320	Arabic Language*	2 (2-0)
4.		Turkish Language*	2 (2-0)
5.		Chinese Language*	2 (2-0)
6.	PHIL-311	Introduction to Philosophy**	2 (2-0)
7.	IS-323	History of Islamic Culture & Civilization**	2 (2-0)
8.	HIS-411	Introduction to History**	2 (2-0)
9.	EDU-414	Introduction to Education**	2 (2-0)

* Any course of regional or international language such as Pashto, Urdu, Arabic, Turkish, Chinese, French or any other language approved by BKUC

** Any other course approved course of BKUC

Head
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Bacha Khan University
Charsadda

TABLE-9 EXTERNAL COURSES OF PHYSICS

S. No.	Course Code	Course Title	Credit Hours
1.	PHY-301	Biophysics	3 (3-0)
2.	PHY-302	Physics-I	3 (3-0)
3.	PHY-303	Physics-II	3 (3-0)

Head
Department of Physics
Bacha Khan University
Charsadda

BKUC-CURRICULUM-BS PHYSICS 2025

YEAR	SEMESTER 1			
1st	Category	Course Code	Course	Credit Hours
	Major	PHY-311	Introductory Mechanics	3 (2-1)
	Major	MATH-311	Calculus – I	3 (3-0)
	General Education	MATH-313	Quantitative Reasoning – I	3 (3-0)
	General Education		Natural Science	3 (2-1)
	General Education	ENG-311	Functional English	3 (3-0)
	General Education	SOC-313	Civics & Community Engagement	2 (2-0)
	General Education		Understanding of Holy Quran-I (Fehm-e-Quran-I)	1 (0-1)
	TOTAL CREDIT HOURS			18
	SEMESTER 2			
	Category	Course Code	Course	Credit Hours
	Major	PHY-321	Waves & Optics	3 (2-1)
	Major	MATH-321	Calculus – II	3 (3-0)
	General Education	MATH-326	Quantitative Reasoning – I I	3 (3-0)
	General Education	ENG-321	Expository Writing	3 (3-0)
	General Education		Pakistan Studies	2 (2-0)
	General Education	IS-312	Islamic Studies (Ethics for non-Muslim students)	2 (2-0)
	General Education		Understanding of Holy Quran-II (Fehm-e-Quran-II	1 (0-1)
	TOTAL CREDIT HOURS			17
2nd	SEMESTER 3			
	Category	Course Code	Course	Credit Hours
	Major	PHY-411	Electricity & Magnetism	3 (2-1)
	Major	PHY-412	Heat & Thermodynamics	3 (2-1)
	Major	MATH-411	Differential Equations	3 (3-0)
	Interdisciplinary	MATH-412	Linear Algebra	3 (3-0)
	General Education		Arts & Humanities	2 (2-0)
	General Education	PS-321	Ideology & Constitution of Pakistan	2 (2-0)
	General Education		Social Sciences	2 (2-0)
	TOTAL CREDIT HOURS			18
	SEMESTER 4			
	Category	Course Code	Course	Credit Hours
	Major	PHY-421	Modern Physics	3 (2-1)
	Major	PHY-422	Classical Mechanics	3 (3-0)
	Major		Vector Calculus	3 (3-0)
	Interdisciplinary	PHY-423	Environmental Physics	3 (3-0)
	General Education	CS-311	Applications of Information & Communication Technologies (ICT)	3 (2-1)
	General Education	MGT-411	Entrepreneurship	2 (2-0)
	TOTAL CREDIT HOURS:			17

3rd	**SEMESTER 5**			
	Category	Course Code	Course	Credit Hours
	Major	PHY-511	Electronics – I	3 (2-1)
	Major	PHY-512	Mathematical Methods of Physics – I	3 (3-0)
	Major	PHY-513	Electromagnetic Theory	3 (3-0)
	Interdisciplinary	PHY-514	Medical Physics	3 (3-0)
	Interdisciplinary	PHY-515	Computational Physics	3 (2-1)
	Interdisciplinary	PHY-516	Scientific Inquiry & Research Methods	3 (3-0)
	TOTAL CREDIT HOURS:			**18**
	SEMESTER 6			
	Category	Course Code	Course	Credit Hours
	Major	PHY-521	Electronics – II	3 (2-1)
	Major	PHY-522	Quantum Mechanics – I	3 (3-0)
	Major	PHY-523	Mathematical Methods of Physics – II	3 (3-0)
	Major	PHY-524	Electrodynamics & Special Relativity	3 (3-0)
	Major	PHY-525	Condensed Matter Physics	3 (3-0)
	TOTAL CREDIT HOURS:			**15**
4th	**SEMESTER 7**			
	Category	Course Code	Course	Credit Hours
	Major	PHY-611	Atomic & Molecular Physics	3 (2-1)
	Major	PHY-612	Quantum Mechanics – II	3 (3-0)
	Major	PHY-613	Nuclear Physics	3 (2-1)
	Major	PHY-	Elective – I	3
	Major	PHY-	Elective – II	3
	Major	PHY-698	Internship	3
	TOTAL CREDIT HOURS:			**18**
	SEMESTER 8			
	Category	Course Code	Course	Credit Hours
	Major	PHY-621	Statistical Mechanics	3 (3-0)
	Major	PHY-	Elective – III	3
	Major	PHY-	Elective – IV	3
	Interdisciplinary	PHY-622	Artificial Intelligence in Physics	3 (2-1)
	Capstone	PHY-699	Capstone	3
	TOTAL CREDIT HOURS:			**15**

SEMESTER 1			
Category	Course Code	Course	Credit Hours
Major	PHY-311	Introductory Mechanics	3 (2-1)
Major	MATH-311	Calculus – I	3 (3-0)
General Education	MATH-313	Quantitative Reasoning – I	3 (3-0)
General Education	*	Natural Science	3 (2-1)
General Education	ENG-311	Functional English	3 (3-0)
General Education	SOC-313	Civics & Community Engagement	2 (2-0)
General Education		Understanding of Holy Quran-I (Fehm-e-Quran-I)	1 (0-1)
TOTAL CREDIT HOURS			18

*** Select course from the pool courses listed below**

PHY- 311 INTRODUCTORY MECHANICS
Credit Hours: Three (3)

Objectives: The main objective of this course is to understand different motions of objects on 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 Contents:

Basic Concepts: Units and Dimensions, SI Units, Inter-conversion of Units; Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products.

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, Conservation of Energy

Head
Department of Physics
Bacha Khan University
Charsadda

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; Rotational inertia of various shapes i.e. for a disc, bar and solid sphere; Elasticity; Stress; Strain and Properties of Materials

Angular Momentum: Angular Velocity; Conservation of angular momentum; effect 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.

Fluid Mechanics: Static Fluids and Pressure; Archimedes' Principle; Fluid Dynamics; Equation of Continuity and Bernoulli's Principle

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).

PHY- 311L MECHANICS

Credit Hours: One (1)

Mechanics and Fluids: Experiments with pendulums, stop watches, one-dimensional motion and verification of Newton's laws of motion, measurement of forces, speed, acceleration and linear momentum, collisions and conservation of momentum, impacts, free fall and

Head
Department of Physics
Bacha Khan University
Charsadda

acceleration due to gravity, gyroscopes, rotational motion, conservation of angular momentum, friction, static and dynamic equilibrium, compound pendulum, rolling motion along inclined planes, simple harmonic motion, masses attached to springs and Hooke's law, damped motion and the regimes of damping (over-damped, under-damped and critically damped), pressure in fluids, experiments demonstrating continuity, Bernoulli's principle, buoyancy and Archimedes's principle, Atwood machine, fluid viscosity, surface tension.

Recommended Books:

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

MATH-311 CALCULUS-I

Credit Hours: Three (3)

Objectives: Calculus I & II focus on the study of functions of a single variable. Calculus serves as the foundation of advanced subjects in all areas of mathematics. This is the first course of Calculus. The objective of this course is to introduce students to the fundamental concepts of limit, continuity, differential and integral calculus of functions of one variable.

Course Contents:

Equations and inequalities: Solving linear and quadratic equations, linear inequalities. Division of polynomials, synthetic division. Roots ofa polynomial, rational roots; Viete Relations. Descartes rule of signs. Solutions of equations with absolute value sign. Solution of linear and on-linear inequalities with absolute value sign.

Functions and graphs: Domain and range of a function. Examples: polynomial, rational, piecewise defined functions, absolute value functions, and evaluation of such functions. Operations with functions: sum, product, quotient and composition. Graphs of functions: linear, quadratic, piecewise defined functions.

Lines and systems of equations: Equation of a straight line, slope and intercept of a line, parallel and perpendicular lines. Systems of linear equations, solution of system of linear equations. Nonlinear systems: at least one quadratic equation.

Limits and continuity: Functions, limit of a function. Graphical approach. Properties of limits. Theorems of

limits. Limits of polynomials, rational and transcendental functions. Limits at infinity, infinite limits, one-sided limits. Continuity.

Derivatives: Definition, techniques of differentiation. Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions. The chain rule. Implicit differentiation. Rates of change in natural and social sciences. Related rates. Linear approximations and differentials. Higher derivatives, Leibnitz's theorem.

Applications of derivatives: Increasing and decreasing functions. Relative extrema and optimization. First derivative test for relative extrema. Convexity and point of inflection. The second derivative test for extrema. Curve sketching. Mean value theorems. Indeterminate
forms and L'Hopitals rule. Inverse functions and their derivatives.

Integration: Anti derivatives and integrals. Riemann sums and the definite integral. Properties of Integral. The fundamental theorem of calculus. The substitution rule.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing 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
6. E. W. Swokowski, Calculus with Analytic Geometry, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRC Press, 2011.
8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/cole, 2004.
9. Calculus by James Stewart

MATH-313 Quantitative Reasoning-I

Credit Hours: Three (3)

Objectives: This course aims to develop the basic mathematical skills which ultimately enhance problem solving skills using inductive and deductive reasoning, Polya's strategy, and sets. The basic concepts will be develop with applications form the real world such as algebraic models with equations, rates, ratios, and percentages will be discussed. Students will also explore linear models, including rectangular-coordinates, functions, empowering them to analyze real-world problems with logical precision. By the course's end, students will have honed problem-solving, logical reasoning, and mathematical modeling abilities to tackle diverse challenges confidently.

Course Contents:

1. Numerical Literacy: Number system and basic arithmetic operations, Units and their conversions, dimension, area, perimeter and volume, Rates, ratios, proportions and percentage Types and sources of data, Measurements scales, Tabular and graphical presentation of data, Quantitative reasoning exercise using number knowledge

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2. Fundamental Mathematical Concepts: Basic of geometry (lines, angles, circles, polygons etc.), Sets and their operations, Relation, function and their graphs, Exponents, factoring and simplyfing algebraic expressions, Algebraic and graphical solutions of linear and quadratic equation 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.

Pool of Natural Sciences Courses

S. No.	Course Code	Course title	Credit Hours
1	BOT-311	Diversity of Plants	3(2-1)
2	ZOO-311	Diversity of Invertebrates	3(2-1)
3	CHEM-315	Inorganic Chemistry	3(2-1)
4	GEOL-566	Fundamentals of Gemology	3
5	HND-104	Global Food Issues	3
6	CHEM-444	Environmental Chemistry	3
7	PHY-313	Physics-I	3(2+1)
8	MATH-313	Mathematics-I	3

S. No.	Course Code	Course title	Credit Hours
1	BOT-311	Diversity of Plants	3(2-1)

Title of the Course: Diversity of Plants
Course Code: BOT-311 **Credit Hours: 3 (2+1)**
Course Objective: To introduce the students to the diversity of plants and

their structures and significance.

Course Learning outcomes:

- Identify major plant groups.
- Describe the structure, function, reproduction, and adaptation of plants.
- Assess the ecological roles and significance of plant diversity in different habitats.

Course Outline

Algae: General Characteristics, Reproduction, classification, adaptation of Algae

Fungi: General Characteristics, Reproduction, adaptation and classification. Ecological role and significance. Implication of fungi on crop production and industrial applications.

Lichens: Introduction to lichens, Ecological role and significance.

Introduction, origin, history, feature and a generalized life cycle of the representative members.

1. Bryophytes
2. Pteridophytes
3. Gymnosperms

Lab Outline

- Identification, morphology and reproductive structures of algae, fungi and lichens specimens.
- Preparation and preservation of specimens slide for microscopic examination
- Identification, morphology and reproductive structures of bryophytes, Pteridophytes and Gymnosperms
- Field trip to study local flora

Recommended Books

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th ed. John Wiley and Sons Publishers.
2. Hussain, F. 2014. Phycology. A Text book of Algae. Pak Book Empire, Lahore.
3. Lee, R.E. 1999. Phycology. Cambridge University Press, UK
4. Mauseth, J.D. 2003. Botany: An Introduction to Plant Biology. 3rd ed., Jones and Bartlett Pub. UK
5. Prescott, L.M., Harley, J.P. and Klein, A.D. 2004. Microbiology, 3rd ed. WM. C. Brown Publishers.
6. Vashishta, B.R. 1991. Botany for Degree Students (all volumes). S. Chand and Company. Ltd. New Delhi.

S. No.	Course Code	Course title	Credit Hours
2	ZOO-311	Diversity of Invertebrates	3(2-1)

Title of the Course: Diversity of Invertebrates

Course code: ZOO- 311 **Credit Hours: 3 (2+1)**

Course Objective

To understand the evolutionary relationships within the animal kingdom, highlighting their phylogenetic linkages and progression from simple to complex forms of life

Course Learning Outcomes

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

- Identify and describe the diversity of invertebrate phyla.
- Analyze the structural and functional adaptations of invertebrates.
- Evaluate the ecological significance and evolutionary history of invertebrates.

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Course Outlines

Introduction:

Classification of organisms; five kingdom classification, evolutionary perspective and tree diagrams; patterns of organization.

Animal-Like Protists: The Protozoa

Classification (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates.

Multicellular and Tissue Levels of Organization

Phylum porifera: cell types, body wall, and skeletons; reproduction.

Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class.

Triploblastics and Acoelomate Body Plan

Phylum Platyhelminthes: classification up to class; the free-living flatworms and the tapeworms;

Aschelminths

Classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of phylum nematoda; Some important nematode parasites of humans.

Annelida

Metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea.

Arthropods

Classification, metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class.

Molluscs. Important characteristics, classification upto class.

Echinoderms: Evolutionary perspective, relationships to other animals; echinoderm characteristics; classification up to class, Ambulacral system, tube feet, larvae

Lab out line

- Study of *Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma, Paramecium* as representative of animal like protists. (Prepared slides).
- Study of sponges and their various body forms.
- Study of principal representative classes of phylum Coelenterata.
- Study of principal representative classes of phylum Platyhelminthes.
- Study of representative of phylum Rotifera, phylum Nematoda.
- Study of principal representative classes of phylum Mollusca.
- Study of principal representative classes of phylum Annelida.
- Study of principal representative classes of groups of phylum Arthropoda.
- Brief notes on medical/economic importance of the following: *Plasmodium, Entamoeba histolytica, Leishmania*, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.
- Collection and preservation techniques, collection of specimens by students.

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 11thEdition (International), 2004. Singapore: McGraw Hill.

2. Miller, S.A. and Harley, J.B. Zoology, 5thEdition (International), 2002. Singapore: McGraw Hill.

3. Pechenik, J.A. Biology of invertebrates, 4 Edition (International), 2000. Singapore: McGraw Hill.

4. Kent, G.C. and Miller, S. Comparative Anatomy of vertebrates. 2001. New York: McGraw Hill

5. Hickman, C.P. and Kats, H.L. Laboratory Studies in integrated principles of Zoology. 2000. Singapore: McGraw Hill

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S. No.	Course Code	Course title	Credit Hours
3	CHEM-315	Inorganic Chemistry	3(2-1)

Course Objective

After completing this course, students will have sufficient knowledge about; the development of periodic law, properties of elements in a systematic way, principal of chemical bonding, concepts of acid and bases and the chemistry of p-block elements.

Course Contents

Periodic Law and Periodicity

Development of Periodic Table; classification of elements based on s, p, d and f orbitals, group trends, periodic properties i.e., atomic radii, ionic radii, ionization potential, electron affinities, electro negativities and redox potential in s, p, d and f block elements

Principles of Chemical Bonding

Types of chemical bonding; ionic bonding; the localized bond approach: valance bond (VBT) theory, hybridization and resonance; MOT theory as applied to Homo-nuclear diatomic and hetero-nuclear molecules, Metallic Bonding, Band Theory of conductors, insulators and semiconductors; bonding in electron deficient compounds; Intermolecular Forces,. Multicentred bonding in electron deficient molecules, three centre two electron bond (3c-2e) and three-centred, four electron (3c-4e) bond models.

Acids and Bases

Concepts of acids and bases including SHAB concept, relative strength of acids and bases, significance of $_{p}$H, $_{p}$Ka, $_{p}$Kb and buffer solutions, solubility, solubility product, common ion effect and their industrial applications.

Chemistry of p-block Elements

Chemistry and structure of p-block elements; main emphasis on the chemistry and structure of noble gases and their compounds, chemistry and structure of interhalogens, pseudo halogens and polyhalides. Prediction of shapes of molecules using VSEPR model and hybridization.

Lab Outline

- Comparative study of different type of inorganic compound.
- Study their molecular structures

Recommended Books

1. Miessler, G. L.; Tarr, D.A., *Inorganic Chemistry*, Prentice-Hall International, New Jersey, USA, 1991.
2. Huheey, J. E.; Keiter, E. A.; Keiter, R. L., *Inorganic Chemistry: Principles of Structureand Reactivity*, 4thed.., Harper and Row, New York,2001.
3. Shriver, D. F.; Atkins, P. W.; Langford, C. H., *Inorganic Chemistry*, 2nd ed., Oxford University Press, 1994.Supplementary Reading Material
4. Cotton, F. A.; Wilkinson, G. *Basic Inorganic Chemistry*, 3rd ed., Wiley, New York, 1995.
5. Lee, J.D., *Concise Inorganic Chemistry*, Chapman and Hall, 5th ed., 1996.

S. No.	Course Code	Course title	Credit Hours
4	GEOL-566	Fundamentals of Gemology	3

Objectives

The course will enable students to fully understand the identification and evaluation of gems and gemstones. After completing this course the students will be able to carry out their independent research on the characterization and genesis of various types of mineral deposits and their economic evaluation.

Course Contents

Gems; basic properties, hardness scale, nature of light, laws of reflection and refraction, refractive indices,

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refractometers. Polarized light and uses of polariscope. Pleochroism, dichroscope, electrical, magnetic and thermal properties of minerals. Specific gravity and methods of determinations.
Colour and causes of colour in gemstones; gemological instrument, special optical properties, chatoyancy, asterism, luminescence play of colors and labradorescence. Inclusions and study of inclusions. Emission and absorption spectroscopy and spectroscopes.
Classification of gemstones, systematic description of crystallography, physical properties, optical properties, absorption spectra, chemical properties, special gemological features, diagnostic features, occurrences of gemstones and gemstones of Pakistan.
Labs: Uses of various instrument needed in gemstones identification; identification of rough and cut gemstones by physical and optical properties.
Recommended Books
1. Decorative Stones: The complete source book by Price, M.T., 2007, Thames and Hudson.
2. Gem Identification Made Easy by Matlins, A.L., 1989, Gemstone Press.
3. Gemology 3rd ed. By Read, P.G., 2005, Elsevier.
4. Gems 6th ed. by O'Donoghue, M., 2006, Butterworth Heinemann.
5. Gems and Precious stones by Lyman, K., 2005, A Fireside Book.
6. Gems: Their source, Description and Identification 4th ed. by Webster, Are, 1983, Butterworth Heinemann.
7. Gemstones, Herbent, G.F., 1977, Chapman and Hall.
8. Gemstones of the World by Schumann, W., 1997, Sterling Publishing Co.
9. Handbook of Gem Materials 5th ed. by Kraus, E.H., 1947, McGraw-Hill.
10. Identification of Gemstones by O'Donoghue, M., 2003, Butterworth Heinemann.
11. Philips Guide to Gems by Oldershaw, C., 2006, Octopus Publishing.
12. Speaking of Healing Through Gems by Saha, N.N., 1995, Sterling Publishers.
13. Synthetic, limitation and Treated Gemstones by O'Donoghue, M, 1997, Butterworth Heinemann.
14. The Spectroscope and Gemology by Andarson, B., 1998, Gemstone Press

S. No.	Course Code	Course title	Credit Hours
5	HND-104	Global Food Issues	3

Learning Outcomes:

- To acquaint knowledge about global food issues having impact on food and nutrition security
- To understand the role of global organizations in food production, consumption and trade
- To study the impact of climate change and other threats on global food availability

Theory:

World food situation; Food and nutrition security; The green revolution: Worldwide post-harvest losses; Global malnutrition: protein energy malnutrition and hidden hunger; Overweight & obesity; Worldwide food price fluctuations; Importance of per capita earning, consumption and purchase power; Irrational food consumption behaviour; Contribution of cereals, legumes, roots, tubers and animal products; World food policy; WTO's trade regulations; Food bioterrorism; International food laws: European and American; Potentials of modern biotechnology to combat food insecurity; Genetically modified foods. Organic, Kosher and Halal Foods; Millennium development goals to sustainable development goals. Global Trends. Climate change.

Suggested Readings:

1. Barbosa-Canovas, G., A. Mortimer, D. Lineback, W. Spices, K. Buckle and P.Colonna. 2009. Global Issues in Food Science and Technology. AcademicPress, Elsevier Inc., Burlington, MA, USA.
2. Barrientos, S. and C. Dolan. 2006. Ethical Sourcing in the Global Food System. Earthscan, New York, USA.
3. Hajra, M.A. 2013. Global Food Security:Emerging Issues and Economic Implications. Nova Science Publishers, New York, USA.

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4. Oosterveer, P. 2007. Global Governance of Food Production and Consumption: Issues & challeng Edward Elgar Publishing Inc., Massachusetts, USA.
5. Phoenix, L.E. and L. Walter. 2009. Critical Food Issues: Problems and State of the Art Solutions Worldwide, Vol. I & 2. ABC-CLIO, LLC, Santa Barbara, California, USA.

S. No.	Course Code	Course title	Credit Hours
6	CHEM-444	Environmental Chemistry	3

Title of the Course: Natural Science: Environmental Chemistry
Course Code: CHEM- 444 **Credit Hours: 3 (2+1)**
Course Objective:

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

- Explain chemical processes occurring in the atmosphere, hydrosphere, and lithosphere with their implications for the environment.
- Analyze sources, fate and transport of pollutants, with a focus on chemical impacts on ecosystems and human health.
- Evaluate strategies for pollution control and sustainable practices in environmental management.

Course Contents:

Atmospheric Chemistry: Composition of atmospheric, temperature and pressure profile. Air pollutants; their sources, sinks and harmful effects. Oxides of N, S and C, Hydrocarbons, radioactivity, atmospheric aerosols, Particulate matter in the atmosphere, Temperature inversion and photochemical smog. Acid rain; mechanism, control measures, effects on buildings and vegetation. Greenhouse effect and Global warming; mechanism, control measures and global impact. Stratospheric ozone; Ozone depletion and its consequences.

Water Pollution and Water Treatment: Sources of water pollution, industrial sources and agricultural sources, heavy metals contamination of water, eutrophication, detergents and phosphates in water. Water quality criteria, Water purification, Primary, Secondary and Advanced water treatments. Removal of nitrogen and phosphorous compounds from polluted water.

Soil Pollution: Composition of soil, Sources of Soil pollution, soil salinity and water logging. Heavy metals contamination of soil, toxicity of heavy metals and bioaccumulation of heavy metals. Renewable Energy resources and Renewable Energy; Nuclear energy, solar, geothermal, tidal energies and Hydrogen economy.

Recommended Books:

1. Manahan, S. E. Environmental Chemistry, 10th ed.; CRC Press: Boca Raton, FL, 2017.
2. VanLoon, G. W.; Duffy, S. J. Environmental Chemistry: A Global Perspective, 4th ed.; Oxford University Press: Oxford, UK, 2018.
3. Baird, C.; Cann, M. Environmental Chemistry, 5th ed.; W. H. Freeman and Company: New York, 2012.
4. Girard, J. Principles of Environmental Chemistry, 3rd ed.; Jones & Bartlett Learning: Burlington, MA, 2013.
5. Harrison, R. M. Understanding Our Environment: An Introduction to Environmental Chemistry and Pollution, 3rd ed.; Royal Society of Chemistry: Cambridge, UK, 2001.
6. Moore, J. W. Environmental Chemistry, 2nd ed.; Academic Press: New York, 1989.
7. Spiro, T. G.; Purvis-Roberts, K. L.; Stigliani, W. M. Chemistry of the Environment, 3rd ed.; University Science Books: Sausalito, CA, 2011. Connell, D. W. Basic Concepts of Environmental Chemistry, 2nd ed.; CRC Press: Boca Raton, FL, 2005
8. Hemond, H. F.; Fechner, E. J. Chemical Fate and Transport in the Environment, 3rd ed.; Academic Press: San Diego, CA, 2015.

9. Peirce, J. J.; Vesilind, P. A.; Weiner, R. F. Environmental Pollution and Control, 4th ed.; Butterworth-Heinemann: Boston, MA, 1997.

Practicals:

Determination of pH, Alkalinity, Hardness, sulfates, chlorides and nitrates in water sample.

Course Code	Course Title	Course Type	Credit Hours
PHY-313	PHYSICS -1	General Education	**03(2+1)**

Objectives

The main objectives of this course are: to provide students with a thorough understanding of the basic concepts of physics and the methods scientists use to explore natural phenomena, including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis. To instruct students of the fundamental laws of physics and the application of scientific data, concepts, and models for use in the natural sciences and real world situations. To provide students with problem solving skills by an approach that describes physical phenomena with relevant mathematical models and formulae.

Course Contents

Vector: Vector notation, vector addition, vectors in the Cartesian coordinate system, scalar product (of two vectors) vector product (of two vectors), scalar of triple product, vector triple product, gradient of a scalar, divergence of a vector, divergence theorem and Stock's theorem; conservation of energy: concept of conservation laws, conservation of energy, worked and kinetic energy, power, conservation forces, rotational energy, potential energy in an electric and gravitational field; dynamics of rigid bodies, center of mass, conservation of angular momentum, equation of motion of rotating body, moment of inertia, perpendicular axes and parallel axis theorems; calculation of moment of inertia for a disc and solid sphere; Euler's theorem, Gyroscope coriolis forces; Inverse Square Law of forces: Newton laws, forces, Newton law of Universal Gravitation b/w point mass and solid spheres, Kepler's laws, satellite in circular orbit escape velocity.

Recommended Books

1. Fundamental of Physics by Jearl Walker, Holiday & Resnick, 10th Edition, Wiley
2. Physics I Practice Problems For Dummies (+ Free Online Practice) by Consumer Dummies. 2015. ISBN 978-1-188-85327-6.
3. Physics I: Mechanics, Waves, and Heat by Michael Thackston. 10th Editiion. Tavenner Publishing Company, 2013. ISBN 193743558X, 9781937435585
4. Physics I: For BPUT by Dr. Mani Naidu. Pearson Education India, 2011. ISBN813179878X, 9788131798782.

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MATH-313 MATHEMATICS-I
Credit Hours: 03

Objectives:

This is the first course of the basic sequence, Calculus I-III, serving asthe foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. Calculus I & II focus on the study of functions of a single variable.

Course Detail:

1. Limits and continuity.
2. Derivative of a function and its applications.
3. Optimization problems.
4. Mean value theorem (Taylor's theorem and the infinite Taylor series with applications) & curve sketching; anti-derivative &integral.
5. Definite integral and applications.
6. The fundamental theorem of Calculus.37
7. Inverse functions (Chapters 1-6 of the text)

RECOMMENDED BOOKS:

1. Anton H, *Calculus: A New Horizon* (6th edition), 1999. John Wiley, New York.
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Thomas G. B, Finney A. R., *Calculus* (10th edition), 2002.Addison-Wesley, Reading, Ma, U.S.A.
4. Anton, H., 1999. *Calculus: A New Horizon*, 6th Edition, John Wiley, New York.
5. Stewart J, 1995. *Calculus, 3rd* Edition, Brooks/Cole
6. Thomas, G. B. and Finney, A. R, 2002. *Calculus*

ENG- 311 Functional English
Credit Hours: Three (3)

Course Description

The subject aims to enhance the students' ability in the meaningful use of grammatical structures. Students will be able to use the targeted grammatical structures meaningfully and appropriately both in oral and written production.

Objectives:

1. To enable students to identify the main/topic sentences.
2. To teach them to use effective strategies while reading the text.
3. To acquaint them about the cohesive devices and their function in the text.

Course Contents:

- Vocabulary (Frequently confused / misused words, Phrases, synonyms, antonyms, idioms & General vocabulary),
- Practical Use of Grammar (Nouns, Pronouns, Verbs, Adjectives, Adverbs, Prepositions, Conjunctions, Articles, Interjections & Tenses),
- Transitive and Intransitive verbs
- Punctuations, 14 American English Punctuations.
- Sentences (Types of sentences, Parts of sentences, Direct and Indirect Speech, Active &

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Bacha Khan University
Charsadda

Passive Voice & Conditional Sentences),

- Composition + Summarization (Describing, Narrating, Argumentation, Short / long Composition)
- Comprehension + Précis writing.
- Phrase, Types of Phrase
- Clause, Types of Clause

Recommended Books:

1. High School English Grammar & Composition by Wren and Martin.
2. Practical English Grammar by A.J. Thomson & A.V. Martinet. Exercises 1 & 2. 3rd edition. Oxford University Press.
3. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand& Francoise Grellet. Oxford Supplementary Skills. 4th Impression 1993.
4. Reading. Upper Intermediate. Brian Tomilson & Rod Ellis. Oxford Supplementary Skills. 3rd Impression 1992.

SOC- 313 Civics & Community Engagement

Credit Hours: Three (3)

Objectives: The overall objectives of this course are to:

1. Teach students the importance and role of active citizenship in promoting a productive, harmonious and developed society/world

2. Educate students about the importance of concepts, skills and philosophy of community linkages in developing a sustainable society

3. Inculcate the importance of community involvement for ensuring an improved, tolerant and generative society/world

4. Provide an opportunity to the students to develop their relationship with the community

Learning Outcomes:

The primary outcome is inclusive development through active citizenship locally and globally,. Moreover, the following are the detailed outcomes of the course based on the three domains of Bloom's Taxonomy i.e Affective, Psychomotor and Cognitive. The students will be able to:

1. Understand the overall organization of the society
2. Recognize and exercise their rights, responsibilities and the significance of active citizenship in positive societal development
3. Identify and critically evaluate social issues and implement practicable community based solutions
4. Understand the concept of human rights and its significance
5. Appreciate diverse viewpoints and inter-cultural harmony

Course Contents:

Introduction to Citizenship Education and Community Engagement

1. Meaning & History
2. Attributes of Active Citizenship
3. Different Approach

i. Republican Approach
ii. Liberal Approach
iii. Cosmopolitan Approach

1. Dimensions of Active Citizenship

i. Rights
ii. Membership
iii. Participation
iv. Identity

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Identity, Culture, and Social Harmony

1. Sociological Theories of Self Formation
i. Sigmund Freud Theory
ii. George Herbert Mead Theory
iii. Charles Horton Cooley Theory
2. Cultural & Religious Harmony
3. Pluralism & Diversity
4. Democracy & Democratic Norms
1. Concept and Development of Identity
2. Components of Cultural and Social Harmony

Inter-Cultural Dialogue (me versus you)

1. Principles & Purpose
2. Ability to Support, learn and share through dialogue
3. Policy Dialogue (encourage young people to share their opinion and perspective with policy makers and opinion makers.

Local & Global Communities

1. Concept of Community
2. Needs, Issues & Conflicts
3. Conflict Resolution
4. Communication & Networking
5. Social Cohesion
6. Social Capital
7. Social Networking
8. Advocacy
9. Social Entrepreneurship & Partnership

Social Action Planning

2. Skills in Project Planning & Management
3. Project Cycle
4. Stakeholder Analysis
5. Problem Identification
6. Writing Project Plan
7. Monitoring & Evaluation
8. Risk Analysis

Population Dynamics in Pakistan

1. Population Growth Pakistan
2. Factors Behind High Fertility Rate
   i. Legislative Actions
   ii. Dearth of Medical Facilities
   iii. Delayed VS Early Age Marriages
   iv. Poverty
   v. Women Empowerment
   vi. Spreading Awareness
   vii. Providing Incentives

- Population Theory

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How to Control Population Growth

Recommended Books:

1. Larsen, A. K., Sewpaul, V., & Hole, G. O. (Eds.). (2013). Participation in community work: International perspectives. Routledge.
2. Alan, T. (2008). Community work, London: Palgrave Macmillan.
3. British Council, (2017) Active Citizen's Social Action Projects Guide (Scotland: British Council.
4. Kaye, C. B. (2004). The complete guide to service learning: Proven, practical ways to engage students in civic responsibility, academic curriculum, & social action. Free Spirit Publishing.
5. Hans, R. (1993). Population Studies, Indian Council of Social Science Research, New Delhi.
6. Demeny, P., McNicoll, G., & Hodgson, D. (2003). Encyclopedia of population. Hodgson, Dennis (2003). Contemporary Population Thought.
7. Peterson, W. (1975). Population, New York, Macmillan.
8. Srinivasan, K. (1998). Basic demographic techniques and applications. SAGE Publications Pvt.
9. UNO (2000). Population Trends, World Population Monitoring, Population growth Structure and Distribution 1999. Department of Economics and Social Affairs, Population Division, UNO.
10. Weeks, J. R. (1992). Population: An Introduction to Concepts and Issues, BelmartCalifornia, Wadsworth Publishing Company.

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SEMESTER 2			
Category	Course Code	Course	Credit Hours
Major	PHY-321	Waves & Optics	3 (2-1)
Major	MATH-321	Calculus – II	3 (3-0)
General Education	MATH-326	Quantitative Reasoning – I I	3 (3-0)
General Education	ENG-321	Expository Writing	3 (3-0)
General Education	PS-321	Pakistan Studies	2 (2-0)
General Education	IS-312	Islamic Studies (Ethics for non-Muslim students)	2 (2-0)
General Education		Understanding of Holy Quran-II (Fehm-e-Quran-II	1 (0-1)
TOTAL CREDIT HOURS			17

PHY-321 WAVES & OPTICS

Credit Hours: Three (3)

Pre-requisites: Mechanics, Calculus II

Objectives: To develop a foundational understanding of oscillations and wave motion in mechanical, electrical, and optical systems, and to apply principles of geometrical and wave optics to analyze interference, diffraction, and polarization phenomena.

Course Contents:

Oscillations: Mass-spring system, simple pendulum, LC circuits, LCR circuit, complex representation, quality factor. Transient and steady-state solutions, resonance in mechanical and electrical systems. Two- and three-mass systems, coupled LC circuits, normal mode analysis, lattice and atomic vibrations.

Wave Motion: Standing waves on strings, sound waves in solids and gases, normal modes, energy transport, phase and group velocities. Wave equations, traveling vs. standing waves in finite and infinite media, transmission lines, boundary effects. Superposition principle, Fourier series and transforms, wave packets, uncertainty and bandwidth. 3D wave equations, plane and cylindrical waves, EM waves, introduction to waveguides, geometric optics laws.

Geometrical Optics: Huygens' Principle, Fermat's principle, reflection and refraction laws. Spherical surfaces, thin lenses, Newton's formula, paraxial approximation. Ray transfer matrices, thick lens analysis, system matrix, cardinal points. Magnifiers, microscopes, telescopes, monochromatic and chromatic aberrations, pupils, stops, distortion.

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Wave Optics: Two- and multi-beam interference, thin films, Michelson and Fabry-Pérot interferometers, free spectral range, resolving power. Fraunhofer diffraction (single slit, circular aperture, gratings), Fresnel diffraction, zone plates, Cornu's spiral. Polarization by reflection and transmission, birefringence, Jones matrices, Brewster's law, dichroism, double refraction.

Advanced Optical Concepts: Temporal and spatial coherence, basic holography of point and extended objects. Stimulated emission, population inversion, gain and threshold, optical resonators, multilayer dielectric mirrors.

Recommended books:

1. J. Pain, The Physics of Vibrations and Waves, Wiley, 6th ed.
2. F. S. Crawford, Waves and Oscillations, Berkeley Physics Course, Vol. 3.
3. F. Pedrotti et al., Introduction to Optics, 3rd ed., Pearson.
4. E. Hecht, Optics, 4th ed., Dorling Kindersley.
5. M. V. Klein and T. E. Furtak, Optics, 2nd ed., Wiley.

MATH-321 CALCULUS-II

Credit Hours: Three (3)

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 Contents:

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

Applications of integrals: Area between curves, average value. Volumes. Arc length. Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology.

Infinite series: Sequences and series. Convergence and absolute convergence. Tests for convergence: divergence test, integral test, p-series test, comparison test, limit comparison test, alternating series test, ratio test, root test. 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.

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Recommended books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing 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
6. E. W. Swokowski, Calculus with Analytic Geometry, PWSPublishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRCPress, 2011.
8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/COLE, 2004.
9. J. Stewart, Calculus early transcendental, 7th Edition,Brooks/COLE, 2008.

MATH-326 Quantitative Reasoning-II

Credit Hours: Three (3)

Objectives: The primary objective of this course is to explore, probability and statistics. The curriculum includes in-depth study of exponential and logarithmic functions, as well as problem-solving related to these mathematical concepts. Solving system of linear equations and matrix algebra is the part of this course which ultimately develops the necessary background for data analysis. Overall, the course aims to equip students with a comprehensive understanding of mathematical concepts relevant to probability and statistics enabling them to apply these skills in real-world scenarios.

Course Contents:

1. **Logic, Logical and critical Reasoning:** Introduction and importance of logic, Inductive, deductive and adductive approaches of reasoning, Proposition Arguments (Valid, invalid) logical connectives, truth tables and propositional equivalences, Logical Fallacies, Venn Diagrams, Predicates and Quantifiers, Quantitate Reasoning exercises using logical reasoning logical reasoning concepts and techniques.

2. Mathematical modeling and Analysis: Introduction to deterministic models, Use of linear function for modeling in real- world situations, Modeling of the system of linear equation and others 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 exercise using statistical modelling.

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.
4. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
5. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6. "Introductory Statistics" by Prem S. Mann.
7. "Applied Statistical Modeling" by Salvatore Babones.
8. "Barrons SAT" by Sharvon Weiner Green, M.A and Ira K.Wolf.

ENG-323 Expository Writing

Credit Hours: Three (3)

Description: 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. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

COURSE LEARNING OUTCOMES

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

1. Understand the essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.
2. Demonstrate mastery of diverse expository types to address different purposes and audiences,
3. Uphold ethical practices to maintain originality in expository writing.

SYLLABUS

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

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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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

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.
7. "Writing to Learn: How to Write-and ThinkClearly About Any Subject at All" by William Zinsser.
8. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg.
9. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan.
10. "Writing Today" by Richard Johnson-Sheehan and Charles Paine.

PS-321 PAKISTAN STUDIES

Credit Hours: Two (2)

Objectives: Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan and to Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Outcomes: The outcome of this subject is purely the understanding of emergence of Muslims in Sub-Continents, Pakistan History, Culture. Society politics and its ideological basis. A part from these considering the national and international politics, this course also thoroughly explains the status and position of Pakistan and its importance in the global village.

The highlighted points are as given below:

1. Advent of Islam in sub-continent
2. The rise and fall of Muslims in India
3. The emergence of imperial power Britain
4. Political emergence of Muslim as nation
5. Role of religion in the freedom movement of Pakistan
6. Geo strategic importance of Pakistan

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Course Contents:

Historical Perspective

1. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i- Azam Muhammad Ali Jinnah.
2. Factors leading to Muslim separatism
3. People and Land
   i. Indus Civilization
   ii. Muslim advent
   iii. Location and geo-physical features.

Government and Politics in Pakistan

1. Political and constitutional phases:
2. 1947-58
3. 1958-71
4. 1971-77
5. 1977-88
6. 1988-99
7. 1999 onward

Contemporary Pakistan

1. Economic institutions and issues
2. Society and social structure
3. Ethnicity
4. Foreign policy of Pakistan and challenges
5. Futuristic outlook of Pakistan

Recommended books:

1. Amin, Tahir. (1999). Ethno-National Movement in Pakistan. Islamabad: Institute of Policy Studies, Islamabad.
2. Burke,S.M and Ziring,Lawrence. (1993). Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press,
3. Mehmood, Safdar. (2001). Pakistan Kayyun Toota. Lahore: Idara-e-Saqafat-e-Islamia. Club Road Press.
4. Mehmood, Safdar. (1994). Pakistan Political Roots & Development. Lahore.
5. Waseem ,Muhammad. (1987). Pakistan Under Martial Law. Lahore: Vanguard. Zaidi,Akbar. S.(2000). Issue in Pakistan's Economy. Karachi: Oxford University

IS-321 ISLAMIC STUDIES

Credit Hours: Two (2)

Objectives: This course is aimed at:

1 To provide Basic information about Islamic Studies

2 To enhance understanding of the students regarding Islamic Civilization

3 To improve Students skill to perform prayers and other worships

4 To enhance the skill of the students for understanding of issues related to faith and religious life.

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Introduction to Quranic Studies

1. Basic Concepts of Quran
2. History of Quran
3. Uloom-ul -Quran

Study of Selected Text of Holly Quran

1. Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2. Verses of Surah Al-Hujrat Related to Adab Al-Nabi(Verse No-1-18)
3. Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4. Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5. Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran

1. Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2. Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3. Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

1. Life of Muhammad Bin Abdullah (Before Prophet Hood)
2. Life of Holy Prophet (S.A.W) in Makkah
3. Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1. Life of Holy Prophet (S.A.W) in Madina
2. Important Events of Life Holy Prophet in Madina
3. Important Lessons Derived from the life of Holy Prophet in Madina

Introduction ToSunnah

1. Basic Concepts of Hadith
2. History of Hadith
3. Kinds of Hadith
4. Uloom –ul-Hadith
5. Sunnah& Hadith
6. Legal Position of Sunnah

Introduction To Islamic Law & Jurisprudence

1. Basic Concepts of Islamic Law & Jurisprudence
2. History & Importance of Islamic Law & Jurisprudence
3. Sources of Islamic Law & Jurisprudence
4. Nature of Differences in Islamic Law
5. Islam and Sectarianism

Islamic Culture & Civilization

1. Basic Concepts of Islamic Culture & Civilization
2. Historical Development of Islamic Culture & Civilization
3. Characteristics of Islamic Culture & Civilization
4. Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1. Basic Concepts of Islam & Science
2. Contributions of Muslims in the Development of Science
3. Quranic& Science

Islamic Economic System

1. Basic Concepts of Islamic Economic System
2. Means of Distribution of wealth in Islamic Economics
3. Islamic Concept of Riba
4. Islamic Ways of Trade & Commerce

Political System of Islam

1. Basic Concepts of Islamic Political System
2. Islamic Concept of Sovereignty
3. Basic Institutions of Govt. in Islam

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Islamic History

1. Period of Khlaft-E-Rashida
2. Period of Ummayyads
3. Period of Abbasids

Social System of Islam

1. Basic Concepts of Social System of Islam
2. Elements of Family
6. Ethical Values of Islam

Recommended books:

1. Bhatia, H.S. (1989). Studies in Islamic Law, Religion and Society.New Delhi: Deep & Deep Publications.
2. Hasan, Ahmad. (1993) .Principles of Islamic Jurisprudence.Islamabad: Islamic Research Institute, IIU.
3. Waliullah, Mir. (1982). Muslim Jrisprudence and the Quranic Law of Crimes. Lahore: Islamic Book Service.
4. Zia-ul-Haq, Muhammad. (2001). Introduction to Al Sharia Al Islamia. Islamabad:Allama Iqbal Open University.

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SEMESTER 3			
Category	Course Code	Course	Credit Hours
Major	PHY-411	Electricity & Magnetism	3 (2-1)
Major	PHY-412	Heat & Thermodynamics	3 (2-1)
Major	MATH-415	Differential Equations	3 (3-0)
Interdisciplinary	MATH-412	Linear Algebra	3 (3-0)
General Education	*	Arts & Humanities	2 (2-0)
General Education	PS-321	Ideology & Constitution of Pakistan	2 (2-0)
General Education	*	Social Sciences	2 (2-0)
TOTAL CREDIT HOURS			18

*** Select course from the pool courses listed below**

PHY- 411 ELECTRICITY & MAGNETISM

Credit Hours: Three (3)

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. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Course Contents:

Coulomb's Law: Coulomb's Law, Charge is Quantized, Charge is conserved

Electric Fields: The Electric Field, The Electric Field Due to a Charged Particle, The Electric Field Due to a Dipole, The Electric Field Due to a Line of Charge, The Electric Field Due to a Charged Disk, A Point Charge in an Electric Field, A Dipole in an Electric Field

Gauss' Law: Electric Flux, Gauss' Law, A Charged Isolated Conductor, Applying Gauss' Law: Cylindrical Symmetry, Applying Gauss' Law: Planar Symmetry, Applying Gauss' Law: Spherical Symmetry

Electric Potential: Electric Potential , Equipotential Surfaces and the Electric Field, Potential due to a Charged Particle, Potential due to an Electric Dipole, Potential due to a Continuous Charge Distribution, Calculating the Field From the Potential, Electric Potential Energy of a System of Charged Particles, 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 Energy.

Capacitors: Capacitance, Calculating The Capacitance, Capacitors In Parallel And In Series, Energy Stored in an Electric Field, Capacitor With a Dielectric, Dielectrics and Gauss' Law.

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Current and Resistance: Electric Current, Current Density, Resistance and Resistivity, Ohm's Law; Power, Semiconductors and Superconductors

Circuits: Single-loop Circuits, Multi- loop Circuits, The Ammeter and the Voltmeter, RC Circuits

Magnetic Fields: Magnetic Fields and the Definition of B, Crossed Fields: Discovery of the Electron, Crossed Fields: The Hall Effect, A Circulating Charged Particle, Cyclotrons and Synchrotrons, Magnetic Force on a Current-Carrying Wire, Torque on a Current Loop, The Magnetic Dipole Moment

Magnetic Fields Due to Currents: Magnetic Field Due to a Current, Force between two Parallel Currents, Ampere's Law, Solenoids and Toroids, A Current-Carrying Coil as a Magnetic Dipole

Induction and Inductance: Faraday's Law and Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductance, Self-Induction, RL 15Circuits, Energy Stored in a Magnetic Field, Energy Density of a Magnetic Field, Mutual Induction

Electromagnetic Oscillations and Alternating Current: LC Oscillations, Damped Oscillations in an RLC Circuit, Forced Oscillations of Three Simple Circuits, The Series RLC Circuit, Power in Alternating-Current Circuits, Transformers

Maxwell's Equations: Magnetism of Matter: Gauss' Law for Magnetic Fields, Induced Magnetic Fields, Displacement Current, Magnets, Magnetism and Electrons, Diamagnetism, Paramagnetism, Ferromagnetism

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,

PHY- 411L ELECTRICITY & MAGNETISM

Credit Hours: One (1)

Static charge and electric fields, direct and alternating currents, electrical measurement instrumentation (voltmeters, ammeters, power supplies, variable transformers, cathode ray oscilloscope, electrometer), passive electronic components (resistors, capacitors, inductors), measurement of resistance, capacitance and inductance, electromagnetic induction, inductors and transformers, motors, magnetic fields due to currents and permanent magnets, ferromagnetism and ferroelectricity, determination of hysteresis curves, determination of Curie point, magnetic susceptibility and its temperature dependence, dielectric properties measurement, mapping of magnetic fields using Hall sensors, experiments on noise, properties of the light bulb.

Recommended books:

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

PHY- 412 HEAT AND THERMODYNAMICS

Credit Hours: Three (3)

Pre-requisites: Mechanics

Objective(s): To understand the fundamentals of heat and thermodynamics

Course Contents:

Basic Concepts and Definitions in Thermodynamics: Thermodynamic system, Surrounding and Boundaries. Type of systems. 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. Reversible and irreversible processes

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Ideal Gases: Brownian motion, Langevin theory and Einstein theory of Brownian motion, Degrees of freedom in mono, di and triatomic molecules, Specific heat of mono, di and polyatomic gases, Critical constants, Boyles temperature, Temperature of inversion, Van der Waals equation of state, Joule's law for perfect gas, Joules coefficient, Joule-Thomson effect, Nature and origin of Van der Waal gases

Transport phenomena in gases: Mean free path, sphere of influence, transport phenomena, viscosity, thermal conductivity

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 states

Thermodynamic Functions: Thermodynamic functions (Internal energy, Enthalpy, Gibb's functions, Entropy, Helmholtz functions), Maxwell's relations, TdS equations, Energy equations and their applications.

Thermodynamics: Zeroth Law of Thermodynamics, Consequence of Zeroth law of Thermodynamics. The state of the system at Equilibrium. First law of thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion. Second law of thermodynamics, Carnot theorem and Carnot engine. Heat engine, Diesel and Petrol engines, Refrigerators. Calculation of efficiency of heat engines. Entropy and Second law of thermodynamics, Entropy and Probability, The T-S diagram. Third law of thermodynamics, Zero-point energy

Thermometry: Heat and temperature, types of thermometers, relationships between scales, Thermoelectricity, Seebeck effect, Peltier effect, Thomson effect, Thermoelectric power, Thermoelectric thermometer

Recommended Books:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999.
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.
6. Brij Lal, N. Subrahmanyam, Heat Thermodynamics and Statistical Physics, Publisher: S. Chand Limited, 2008

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Bacha Khan University
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PHY-412L HEAT AND THERMODYNAMICS

Credit Hours: One (1)

Heat: Calorimetry, heat transfer, Newton's cooling under ambient and forced convection and radiation, measurement of temperature using Si diodes, thermistors, thermocouples and RTD's, black bodies, heat pumps and heat engines, investigation of gas laws and laws of thermodynamics, thermal conductivity by pulsed heating of a metal rod, measurement of latent heats and specific heat capacities, temperature control using proportional-integral-derivative (PID) schemes, thermal expansion and its measurement using strain gauges.

Waves and Oscillations, Sound: Resonance in a stretched string, normal modes of oscillation, dispersion relations for mono- and di-atomic lattices, coupled oscillators, nonlinear oscillations exemplified by resistance-inductance-diode circuits, magnetic pendulums, accelerometers, measurement of the speed of sound under conditions of varying temperature, solitons, Lorentz pendulum, waves in water, beats, superposition of harmonic motion (Lissajous patterns), sonometer.

Recommended Books:

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

MATH-415 Differential Equation

Credit Hours: Three (3)

Introduction to ODEs (physical motivation), First order ODEs (separable variables, homogeneous equations, exact equations, linear equations, Bernoulli equation and other examples), applications of first order ODEs linear and non-linear, 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

Head
Department of Physics
Bacha Khan University
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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), Laplace transform (Laplace transform and its inverse and properties, use in solving differential equations, Dirac delta function).

Recommended Books:

1. D. G. Zill and M. R. Cullen, "Differential Equations with Boundary Value Problems", 3rd ed. National Book Foundation.
2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. 1999.
3. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press 2006.

MATH-412 Linear Algebra

Credit Hours: Three (3)

Objective(s): Linear algebra forms the basis for modern mathematics- theoretical, applied and computational. The purpose of this course is to provide students a broad and solid foundation for study of advance mathematics, and it applications in diverse field of science and engineering.

Course Contents:

Algebra of matrices, Row and Column operations, rank, inverse of matrices, Transformation, Linear transformation, matrix of a linear transformation. group of matrices and Subgroups, orthogonal transformation, Linear operators. Canonical form of the matrix of a nilpotent operator. Polynomial algebra and canonical form of the matrix of an arbitrary operator. Rings, field, finite and infinite fields (definition and examples), Homomorphism of fields, annihilators, vector spaces, subspaces, Linear combination, Linear dependence and independence, linear span of a subset of a vector space, bases and dimensions of a vector space, Null space, nullity, dimension, Relation of rank, dimension and nullity. Eigen value, eigenvector, eigen value problem with physical Significance, Similar matrices with eigen values, Inner product spaces. System of differential equations in normal form. Homogeneous linear systems. Solution by diagonalisation. Non-homogeneous linear systems.

Recommended Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press 2006. 1. D.T. Finkbeiner, Introduction to Matrices and Linear Transformations, 3rd. Ed., N.H.
2. Freeman and company San Francisco, 1978.
3. D. C. Lay, Linear Algebra and Its Applications, Addison-Wesley, 3rdEdition, 2005.
4. A. M. Tropper,Linear Algebra, Thomas Nelson & Sons, 1973.
5. S. Lang, Linear Algebra, Addison-Wesley, 1970.
6. K. R. Hoffman and R. Kunze, Linear Algebra , Prentice Hall, 1971.
7. I. N. Herstein, Topics in Algebra, Addison-Wesley, 1980.
8. T. S. Blyth, E. F. Robertson, Essential student Algebra, Vol I-V, Chapman & Hall, 1986.

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9. Anton H, Linear Algebra with Applications (8th edition), John Wiley, New York

10. Hill RO, Elementary Linear Algebra with Application (3rd edition), 1995,Brooks/Cole
11. Leon SJ, Linear Algebra with Applications (6th edition), 2002, Prentice Hall,
12. Englewood Cliffs, NJ, USA
13. Nicholson WK, Elementary Linear Algebra with Applications (2nd edition), 1994, PWS Publishing Co.

***POOL OF ARTS & HUMANITIES COURSES**

S. No.	Course Code	Course title	Credit Hours
1	PHIL-311	Introduction to Philosophy	02
2	PASH-324	Pashto Language: Introduction andDevelopment	02
3	EDU-414	Introduction to Education	02
4	IS-320	Arabic Language	02
5	CHI-321	Basic Chinese Language	02

***POOL OF ARTS & HUMANITIES COURSES**

S. No.	Course Code	Course title	Credit Hours
1	PHIL-311	Introduction to Philosophy	02

Course Objectives:

- Understanding basic concepts of philosophy in the fields of metaphysics, axiology, and epistemology.
- Understanding of philosophical terms.Course Contents: 1. Introduction

What is Philosophy?

i. Subject matter of philosophy
ii. Main branches of philosophy
iii. The methods of philosophy
iv. Important of philosophy

Religion and Philosophy

i. Arguments for the existence of God
   - Teleological Argument
   - Cosmological Argument
   - Ontological Argument

ii. Problem of Evil
iii. Faith and Reason

Theories of knowledge

i. Rationalist theory of knowledge
ii. Empiricist theory of knowledge
iii. Kant's theory of knowledge

Meta physics

i. Ontology
ii. Cosmology

Moral Philosophy

i. Utilitarianism
ii. Emotivism
iii. Deontological ethics

Logic & Critical Thinking

i. Logic definition and scope

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ii. Inductive logic
iii. Deductive logic

Philosophical Theories

i. Materialism
ii. Idealism
iii. Realism
iv. Romanticism
v. Existentialism

Recommended Books:

1. Stewart, D. & Blocker, H. G. (2006). Fundamentals of Philosophy. (6th Edition). PearsonEducation.
2. Bertrand, Russel, A History of Western Philosophy, London, Allen & Unwin, 1957.
3. Will Durant
4. Philosophy and the Social Problem New York: Macmillan.
5. *The Story of Philosophy*. *New York: Simon & Schust*

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***POOL OF ARTS & HUMANITIES COURSES**

S. No.	Course Code	Course title	Credit Hours
2	PASH-324	Pashto Language: Introduction andDevelopment	02

Arts and Humanities –I (Language) Pashto Course Pool

For other Disciplines

پښتو ژبه: پېژندګلو او پرمختګ

Pashto Language: Introduction and Development

Course Title	پښتو ژبه: پېژندګلو او پرمختګ Pashto Language: Introduction and Development
Course Code	PASH.324
Semester	2nd
No. of Credit Hours	02
Objectives	1. دا کورس د پښتو زده کونکيو تر څنګ د نورو څانګو د پاره مه دے ځکه پکښې د پښتو تعارف په لړ کښې ابتدايي مواد شامل دي چې دوي د پښتو د ابتدايي نقوشو نه خبر شي 2. زده کونکي د پښتو د ليک دود سره اشنا کول 3. زده کونکي د پښتو ژبې او قام په اساسي نظرياتو خبرول 4. زده کونکي د پښتو ادب او پښتو نوموړو شاعرانو د ژوند او شاعرۍ نه خبرول

Course Contents	• املاء او رسم الخط کښې فرق
	• د رسم الخط مختلف قسمونو بيان
	• د پښتو املاء ارتقاء
	  • پښتو املاء کښې روښاني اختراعات
	  • پښتو املاء ته د خوشحال خان خټک بخښنې
	  • د باړه ګلې سيمنارونه او پښتو املاء
	  • د پښتو د املاء او رسم الخط په لړ کښې انفرادي کوششونه
	• د پښتو ژبې په اړه بېلابېلې نظريې
	(سامي النسل نظريه- اريايي نظريه- پښتانه بني اسرائيل دي؟- پښتانه اريا دي؟)
	• د نوموړو پښتو شاعرانو د ژوند احوال:
	(خوشحال خان خټک- رحمان بابا- حميد بابا- کاظم خان شېدا- حمزه بابا- غني خان- اجمل خټک- قلندر مومند)
	• د لاندينو شاعرانو د ورکړو شوو غزلونو تشريحات:
	  ○ توره چې تېريوي خو ګزار لره کنه — خوشحال خان خټک
	  ○ په نبه خوي له بد خواهانو بې پروا يم — رحمان بابا
	  ○ د ستا د شونډو په څېر کله دې د ګل رنګ — حميد بابا

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○ د يارانو د هجران له جور و جرمه ○ ستا غمونه به ختمپږي هم که نه ○ پوهه مې او زده کړه مې د مينې له آئينه ده اعظم اعظم • د لاندينو افسانه نګارونو د افسانو فني او فکري جايزه ○ قلندر مومند: ګجرې ○ زيتون بانو: ژوندي غمونه	علي خان حمزه بابا ډاکټر محمد	

مجوزه کتابونه:

1. ليکوالي املا او انشاء ، از ګل باچا الفت
2. د خيرالبيان ليک دود ، مشموله خپرالبيان، کابل چاپ، پوهاند عبدالشکور رشاد ، مخ ۵۵ تا ۸۰ پورې
3. پښتو ليک دود ، از پريشان ختک
4. پښتو املاء ، پروفيسر ډاکټر راج ولي شاه ختک
5. پښتو ليک دود ، از خان شهيد عندالصمد خان
6. معياري پښتو ، ډاکټر عبدالرزاق پالوال
7. پښتو ليک دود ـــــــ ډاکټر نصرالله جان ـــ پښتو اکېډيمي
8. ساهو پښتو ـــــــــــ مشتاق مجروح
9. پښتانه ليکوال ـ همېش خليل
10. د ياد شوو شاعرانو د شاعرۍ د ډوا وين/شعري ټولګې

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S. No.	Course Code	Course title	Credit Hours
3	EDU-414	Introduction to Education	02

Pool Course: Arts & Humanities-II
Course Title: Introduction to Education
Course Code: EDU-414
Credit Hours: 03

COURSE CONTENTS:

Introduction:

- Meaning and Definition of Education
- Importance of Education
- Modes of Education.

Foundation/Perspectives of Education:

- Philosophical
- Psychological
- Socio-Cultural, and
- Economic

Instructional Objectives:

- Goals
- Aim
- Objectives
- Importance of Learning Objectives.
- Taxonomy of educational Objectives.

Teaching Methodology:

- Traditional
- Modern
- Instructional Material.
- Instructional Techniques.

Class Room Management:

- Criteria for students classification
- Need for classification
- Psychological factors of classification in system of examination.

Learning:

- Introduction
- Meaning and Definition
- Nature of Learning.
- Factors effecting learning.
- Approaches of Learning (Behavioral and Cognitive).

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Educational Guidance and Counseling:

- Definition and Nature of Guidance.
- Role and Function of Guidance.
- Counseling and its Principles.

COURSE RECOMMANDED BOOKS:

1. Elias, John L. and Merriam, Sharan.(1984). Philosophical Foundation of Education. Malabar Florida: Krieger Publishing Company.
2. Friere, P.(1970). Pedagogy of the Oppressed: What we Consume. W.W.F and Richmond Publishing Company.
3. Gutek, Gerald L. (1988). Philosophical Thinking in Educational Practice. Westport: Con,Praeger Publisher.
4. Iqbal, M. (2001). Reconstruction of Religion Thoughts in Islam.National Education policies, (1972, 1979, 1998, 2010).

***POOL OF ARTS & HUMANITIES COURSES**

S. No.	Course Code	Course title	Credit Hours
4	IS-320	Arabic Language	02

Title	Description
Course Name	Arabic language
Course code	IS-320
Nature of Course	Art & Humanities (General Course)
No. of C. Hrs	02
Teaching weeks	16
Objectives of the Course	ا۔ طلباء کو عربی زبان کی اہمیت سے آگاہ کرنا۔ ب۔ طلباء کو علم صرف اور نحو کے بنیادی قواعد سے آگاہ کرنا تاکہ اسلامی علوم سے کماحقہ استفادہ کیا جاسکے۔ ت۔ طلباء کو علم صرف کے بنیادی اصولوں سے آگاہ کرنا۔

Course Description

S.No	Topic	Description
1	عربی زبان کا تعارف واہمیت	ا۔ عربی زبان کا آغاز اور ارتقاء۔ ب۔ عربی زبان کی اہمیت اور علوم اسلامیہ کے فہم میں عربی زبان کا کردار۔
.2	مفرد کی تعریف اقسام اور علامات	الف۔ مفرد، اسم، فعل اور حرف کی تعریف اور اقسام ب۔ اسم، فعل اور حرف کی علامات
.3	مرکب ، اسم معرفہ	الف۔ مرکب کی تعریف اور اس کے اقسام ب۔ اسم معرفہ اور نکرہ کی تعریف اور اقسام
.4	ماضی اور مضارع	۔ فعل ماضی اور مضارع کا تعارف اقسام اور گردانیں ت۔ فعل ماضی اور مضارع کے بنیادی صرفی قواعد۔
.5	فعل امر و نہی	ا۔ فعل امر و نہی کا تعارف، اقسام اور گردانیں۔ ب۔ فعل امر و نہی کے بنیادی صرفی قواعد۔
.6	اسماء 1	ا۔ اسم فاعل کا تعارف اور صرفی قواعد۔ ب۔ اسم مفعول کا تعارف اور صرفی قواعد۔
.7	اسماء 2	ا۔ اسم تفضیل اور اسم آلہ کا تعارف اور صرفی قواعد۔ ب۔ اسم ظرف (زمان و مکان) کا تعارف اور صرفی قواعد۔
.8	اسماء 3	ا۔ اسم اشارہ (قریب اور بعید)۔ ب۔ اسم موصول اور جملہ موصولہ کا تعارف۔
.9	معرب و مبنی	ا۔ اسم معرب کا تعارف اور اس کی اقسام۔ ب۔ اسماء مبنی کا تعارف اور ان کی اقسام۔
.10	حروف	ا۔ حرف نداء اور حروف جوازم مضارع۔ ب۔ حروف نواصب مضارع۔
.11	ثلاثی مجرد	ا۔ فعل ثلاثی مجرد کا تعارف۔ ب۔ فعل ثلاثی مجرد کے ابواب۔

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.12	ثلاثی مزید فیہ (ا)	ا۔ فعل ثلاثی مزید فیہ کا تعارف۔ ب۔ فعل ثلاثی مزید فیہ کے ابواب۔
.13	)۲(ثلاثی مزید فیہ	ا۔ ثلاثی مزید فیہ کے ابواب کا تفصیلی مطالعہ۔
.14		ا۔ صحیح اور مثال (واوی۔یائی) ب۔ مضاعف اور لفیف (مفروق اور مقرون)
.15	ہفت اقسام (ب)	ا۔ناقص (واوی۔یائی) ب۔ مہموز (الفاء والدین واللام) اوراجوف۔
.16	ضمائر، اسم تصغیر اور اسم منسوب	الف۔ ضمائر تعریف اور کی اقسام ب۔اسم تصغیر اور منسوب

نصابی کتب

نمبر شمار	نام مصنف	نام کتاب
1.	عبد الستار	عربی کا معلم۔(چاروں حصّے)
.2	معین اللہ ندوی۔	۔تمرین صرف
.3	محمد مصطفیٰ ندوی۔	۔تمرین نحوا
.4	مولانا عبد الماجد ندوی۔	۔معلم الانشاء
.5	مولانا مختار احمد۔	۔مختار النحو

حوالہ جاتی کتب

نمبر شمار	نام مصنف	نام کتاب
1	علی جارم۔	النحوالواضح
.2	نعیم الرحمن۔	اساس عربی
.3	رشید الشرطوتی۔	۔مبادی العربیہ فی الصرف النحو
.4	عبد الرحمن امر تسری۔	۔کتاب النحو
.5	محمد مصطفیٰ ندوی۔	۔تمرین النحو
.6	عبد الرحمن طاہر۔	۔قواعد القرآن
.7	جامعۃ الملک السعود، ریاض۔	۔اللغۃ العربیۃ لغیر الناطقین بھا

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S. No.	Course Code	Course title	Credit Hours
5	CHI-321	Basic Chinese Language	2

Basic Chinese Language
Course Outline

Programme	Undergraduate	Course Code	CHI-321	Credit Hours	2
Course Title	Basic Chinese Language				

Course Introduction

This course is planned to introduce the basics of Chinese language to students at beginner level. It will include simple sentences, instructions and descriptions used in everyday life. To achieve this objective basic vocabulary and usual dialogues will be used.

Learning Outcomes

On the completion of the course, the students will:

1. Be able to communicate in Chinese language
2. Make sentences in Chines language
3. Have situational dialogues
4. Write paragraph and short essays
5. Speaking and pronunciation

Course Content		Assignments/Readings
Week 1	Introduction to Chinese Language	
	How do you do? Glade to meet you	
Week 2	Counting	
	Date	
Week 3	Colours	
	Fruits/Vegetables	
Week 4	How is your health?	
	Exercises/Practice	
Week 5	Are you busy with your work?	
	Exercises/Practice	
Week 6	May I know your name?	
	Exercises/Practice	
Week 7	Let me Introduce?	
	Exercises/Practice	

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Week 8	How many people are there in your family?	
	Exercises/Practice	
Week 9	What time is it?	
	Exercises/Practice	
Week 10	I want to buy.	
	Exercises/Practice	
Week 11	What's your Nationality? Where are you from?	
	Countries	
Week 12	What would you like to have?	
	Talking about hobbies	
Week 13	Directions	
	Exercises/Practice	
Week 14	At the restaurant	
	Exercises/Practice	
Week 15	Measure Words	
	Exercises/Practice	
Week 16	Asking age and marriage	
	Exercises/Practice	

Textbooks and Reading Material

1. Textbooks.

- Conversational Chinese 301 by Beijing Language and Culture University Press
- New Practical Chines Reader Text book1 (2007). Edited by Liuhehui. Beijing Language and Culture University Press, China

2. Lets Learn Chinese Together(2016)

Teaching Learning Strategies

1. Lectures
2. Discussion
3. Group Work
4. Listening

Assignments: Types and Number with Calendar

1. Weekly vocabulary quizzes
2. Bi-weekly written assignments
3. Oral presentations on given topics
4. Midterm and final exams

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	30%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	20%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	50%	Written Examination at the end of the semester. It is mostly in the form of a test.

***POOL OF SOCIAL SCIENCES COURSES**

S. No.	Course Code	Course title	Credit Hours
1	POL-324	Introduction to Political Science	02
2	PSY-311	Fundamentals of Psychology	02
3	EC-310	Introduction to Economics	02
4	SOC-316	Introduction to Sociology	02
5	IR-315	Introduction to International Relations	02

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Course Name: Introduction to Political Science	
Course Code: POL-314	**Credit Hours: 02**

COURSE DESCRIPTION

The course provides an early conceptual exercise to students in Political Science. The course begins with the elementary discussion of what political science is; what is the scope of the subject and its core concepts. It teaches students about the origin and nature of the central concern of political science – the state. It challenges the students' view of what constitutes political power and its various manifestations. Lastly, it familiarizes the students with the idea of government and its operations.

OBJECTIVES

The objective of this course is to introduce the students with the fundamentals of the subject of Political Science and prepare them for advanced studies in the forthcoming semesters. The very basic concepts and terminology commonly used in the further courses of studies are taught to make the students friendly with the subject.

COURSE CONTENTS

1. Definition of Political Science.
2. Nature of Political Science.
3. Scope of Political Science.
4. Relationship of Political Science with other social sciences.
5. State: its origin and evolution; Western and Islamic concepts of State.
6. Organs of Government: Legislature, Executive, Judiciary.

COURSE RECOMMANDED BOOKS:

1. Ahmad, Sheikh Bashir. Riyasat Jo Ilm (Sindhi meaning Science of State). Jamshoro Institute of Sindhalogy, University of Sindh, 1985.
2. Mazher ul Haq. Theory and Practice in Political Science. Lahore: Bookland, 1996.
3. Ian Mackenzi (Ed.). Political Concepts: A Reader and Guide. Edinburgh, University Press, 2005.
4. Mohammad Sarwar, Introduction to Political Science, Lahore: Ilmi Kutub Khana, 1996.
5. R. C. Agarwal, Political Theory (Principles of Pol. Science). New Delhi: S. Chand & Co., 2006.
6. Robert Jackson and Dorreen Jackson, A Comparative Introduction to Political Science, New Jersey, Prentice – Hall, 1997.
7. Rodee Anderson etc. Introduction to Political Science. Islamabad: National Book Foundation, Latest Edition.
8. Roskin, Michael G. Political Science: An Introduction. London: Prentice Hall, 1997.
9. Shafi, Choudhry Ahmad. Usul-e-Siyasiat (Urdu). Lahore Standard Book Depot, 1996.
10. V. D. Mahajan. Political Theory- Principles of Political Science. New Delhi: S. Chand & Co., 2006.

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Course Code	Course Title	Course Type	Credit Hours
PSY-311	Fundamentals of Psychology	General Education	02

Course Description

This course provides some basic knowledge of the key terms, facts and principles designed to aid the students in understanding individual behaviour. Behaviour is analyzed and interpreted through activities and discussion of such topics as motivation, emotion, perception, learning and intelligence.

Course Objectives:

- To describe psychology with major areas in the field,
- To identify the parameters of this discipline. Distinguish between the major perspectives on human thought and behavior. Appreciate the variety of ways psychological data are gathered and evaluated.
- To gain insight into human behavior and into one's own personality or personal relationships. Explore the ways that psychological theories are used to describe, understand, predict, and control or modify behavior.

Course Outlines:

1. **Introduction to Psychology:**
   a) Nature and Application of Psychology with special reference to Pakistan.
   b) Historical Background and Schools of Psychology (A Brief Survey)
   c) Specializations and branches of Psychology
2. **Methods of Psychology**
   a. Observation
   b. Case History Method Experimental Method
   c. Survey Method
   d. Interviewing Techniques
3. **Sensation**
   a. Characteristics and Major Functions of Different Sensations
   b. Vision: Structure and function of the Eye
   c. Audition: Structure and functions of the Ear
4. **Perception**
   a. Nature of Perception
   b. Factors of Perception: Subjective, Objective and Social
   c. Kinds of Perception
   d. Spatial Perception
   e. Temporal Perception; Auditory Perception
5. **Motives**
   a. Definition and Nature
   b. Classification
   c. Primary (Biogenic) Motives: Hunger, Thirst, Defection and Urination, Fatigue, Sleep, Pain, Temperature, Regulation, Maternal Behavior, Sex
   d. Secondary (Socio-Genic) Motives: Play and Manipulation, Exploration and Curiosity, Affiliation, Achievement and Power, Competition, Cooperation, Social Approval and Self Actualization.
6. **Learning**
   a. Definition of Learning
   b. Types of Learning: Classical Operant Conditioning, Methods of Learning: Trial and Error; Learning by Insight; Observational Learning
7. **Memory**
   a. Definition and Nature
   b. Memory Processes: Retention, Recall and Recognition
   c. Forgetting: Nature and Causes

Recommended Books:

1. Atkinson R. C., & Smith E. E. (2000). Introduction to psychology (13th ed.). Harcourt Brace College Publishers.
2. Fernald, L. D., & Fernald, P. S. (2005). Introduction to psychology. USA: WMC Brown Publishers.
3. Glassman, W. E. (2000). Approaches to psychology. Open University Press. Hayes, N. (2000). Foundation of psychology (3rd ed.). Thomson Learning. Lahey, B. B. (2004). Psychology: An introduction (8th ed.). McGraw-Hill Companies, Inc.
4. Leahey, T. H. (1992). A history of psychology: Main currents in psychological thought. New Jersey: Prentice-Hall International, Inc.
5. Myers, D. G. (1992). Psychology. (3rd ed.). New York: Wadsworth Publishers.
6. Ormord, J. E. (1995). Educational psychology: Developing learners. Prentice- Hall,Inc

Title of the Course: Social Sciences: Introduction to Sociology

Course Code: Soc-316 **Credit Hours: 02 (2+0)**

Course Objective

To equip student with the basic concepts of sociology and various social phenomenon.

To familiar the students with social process on the basis of which society is smoothly functioning

To train students to understand and interpret objectively the role of social process, culture and socialization in their lives.

Course contents:

Introduction

- Introduction, Scope, Nature, and Subject Matter of Sociology
- Historical background
- Sociology as a Science
- Relationship of Sociology with other Social Sciences
- Sociological perspectives in Sociology.
- Role of Sociologists in Society.

Group, Community and Society

- Definition, elements, characteristics of community and society.
- Difference between society and community.
- Various types of societies.
- Difference between rural and urban community.
- Definition and types of social group.

Culture

- Definition, aspects, characteristics, elements, and types of Culture
- Norms, values and social sanctions
- Cultural Universality, Variability, Relativism, Ethnocentrism and Xenocentrism
- Cultural Lag

Socialization & Personality Development

- Meaning, definition and Agencies of Socialization.
- Meaning and definition of self.
- Meaning, definition and types of Personality
- Responsible Factors in Personality Formation.
- Theories of socialization, self and personality development.

Role and Status

- Definition and types of role.
- Definition and types of status.
- Determinants of status

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Charsadda

Social Processes

- Social interaction and forms of social interaction
- Cooperation
- Competition
- Conflict
- Assimilation and acculturation
- Accommodation

Social Stratification and Mobility

- Introduction, Definitions, Determinants and types of social stratification.
- Difference between caste and class.
- Introduction, meaning and definition of social mobility.
- Dynamics and types of social mobility
- Difference between mobility and migration

Collective Behaviors and Social Movements

- Meaning, definitions, types and nature of collective behaviors.
- Meaning, definitions, types of Crowed.
- Meaning, definitions, kinds and life cycle of social movements

Course Recommended Books:

1. Ballantine, Jeanne H. and Roberts, Keith A. (Condensed Version) 2010. *Our Social World.* California: Pine Forge Press/Sage Publication.
2. Brown, Ken 2004. *Sociology*. United Kingdom: Polity Press
3. Brym, Robert J. and Lie, John. *Sociology: Your compass for a new world* (Brief Edition) 2007 Belmont: Thomson Wadsworth.
4. Colander, David C. and Hunt, Elgin F. (Thirteenth Edition) (2010) *Social Sciences: An introduction to the study of Society.* India: Pearson Education/Dorling Dindersley.
5. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
6. Rao, C. N. Shankar (2008) 'Sociology: Principles of Sociology with an Introduction to Social Thoughts' New Delhi: S. Chand & Company.
7. James M. Henslin. (2004). *Sociology: A Down to Earth Approach*. Toronto: Allen and Bacon.
8. Macionis, John J. (2006). 10th Edition *Sociology* New Jersey: Prentice-Hall
9. Montuschi, Eleonora. (2006). *The Objects of Social Sciences* New York: Continuum.
10. Hortun, Paul B. and Hunt, Chester L. 1984. *Sociology.* New York: McGraw-Hill,

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COURSE TITLE: INTRODUCTION TO ECONOMICS
COURSE CODE: EC-414
CREDIT HOURS: 02

COURSE DESCRIPTION

Introduction to Economics is an introductory undergraduate course that teaches the fundamentals of economics. This course introduces microeconomic concepts i.e. supply and demand analysis, theories of the firm and individual behaviour, competition and monopoly, and Macroeconomics concepts i.e. macroeconomic indicators and issues such as national income, unemployment, inflation etc.

Students will be introducing to the use of microeconomic and macroeconomic applications to address problems in current economic policy throughout the semester. The course will rely heavily on graphical analysis and simple numerical calculations.

COURSE OBJECTIVES

By the end of the course, students will be able to understand introductory microeconomic and macroeconomic theory, solve basic micro and macro-economic problems, and use these techniques to think about a number of basic policy questions relevant to the operation of the economy. More specifically, this course aims:

- To develop an understanding of introductory microeconomic theory and its relevance to the real word
- To sharpen the problem solving tactics required to solve basic microeconomic/Macroeconomic problems
- To give a broader implications of micro and macro-economic principles and their applications
- To train the students to work with others as a part of team to solve problems

COURSE LEARNING OUTCOMES:

After completing this course, students should have developed a range of skills enabling them to understand economic concepts and use those concepts to analyse specific questions. By the end of this course, students should be able to:

- Understand consumer and firm behaviour apply graphical analysis for a variety of economic situations.
- Calculate and Interpret elasticities
- Define and derive short-run and long run production costs
- Explain various market structures

COURSE CONTENT

1.1 The Economic Problem
1.2 Economic Decision Makers
1.3 The Circular Flow Model
1.4 Distinction between Microeconomics and Macroeconomics
1.5 The Market System

2. Demand & Supply:

2.1 Demand Function, Demand Curve, Engel Curve, Changes in Demand, Law of Demand, shift in Demand, Factors Affecting Demand, Consumer Surplus

2.2 Supply, Supply Function, Supply Curve, Changes in Supply, Factors Affecting Supply, Law of Supply, Producer Surplus

2.3 Equilibrium of Demand and Supply, Market Equilibrium, Price Controls, Taxes and Subsidies

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3. Elasticity of Demand & Supply:

3.1 Price Elasticity of Demand & Supply
3.2 Point Elasticity of Demand & Supply
3.3 Arc Elasticity of demand & Supply
3.4 Income Elasticity of Demand & Supply
3.5 Cross Elasticity of demand & Supply

4. Consumer Behavior:

4.1 Utility Analysis (Cardinal Approach), Marginal Utility
4.2 Law of Diminishing Marginal Utility and Law of Equi-Marginal Utility, Consumer Equilibrium

5. Introduction to Macroeconomics
5.1 What is macroeconomics and how economist thinks?
5.2 The economy in aggregate,
5.3 Complexities of the world of business,
5.4 Scope of macroeconomics,
5.5 Brief account of classical and the development of macro-economic after the World War-II
5.6 Concept of business cycles: Boom and Depression,
5.7 Three concerns of macroeconomics, Inflation, GDP growth and unemployment,
5.8 Macroeconomic variables and their mutual relationship,
5.9 Macro-models as abstraction from the real economy.

6. National Income Accounting:

6.1 Definition and concept of national income,
6.2 Measures of national income: Gross Domestic Product (GDP) and Gross National Product (GNP), GDP at factor cost and at market prices, GDP deflator
6.3 Computation of national income: Product, Income and Expenditure approaches,
6.4 Circular flow of income,
6.5 Nominal versus Real income,
6.6 Per capita income and the standard of living.
6.7 Measuring the cost of living: the consumer price index, CPI versus GDP deflator
6.8 Measuring Unemployment rate

7. Components of Aggregate Demand:

7.1 The Concept of Open and closed economy models,

TEACHING METHODOLOGY:

Lectures
In Class Activities Written Assignments

TEXT AND REFERENCE BOOKS:

1. Michael J. Swann, William A. McEachern Microeconomics: A Contemporary Introduction, 3rd edition (or latest available)
2. Mankiw N. Gregory, Principles of Microeconomics 7th edition (or latest available).
3. Campbell R. McConnell, Stanley L. Brue, Principles of Economics, 17th edition (or latest available).
4. Paul A. Samuelson, William D. Nordhaus, Economics, Latest Edition

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Course Name: Introduction to International Relations

Course Code: IR-315	**Credit Hours: 02**

Course Objectives:

The course has been design to provide in-depth knowledge about the contemporary world and nature of relationship among the states *Viz-a-viz* nations. The students will be able to see the world with theoretical as well as practical perspectives.

Course Outlines

Introduction

Meaning, Definition and Scope of International Relations.

Nation State: Sovereignty and Security.

Approaches and Theories in International

relations The role of Power & National Interest;

Concept of Balance of Power.

Concept of Collective Security.

State and Non-State Actors.

Peace through Political Methods

Diplomacy and Negotiations

International Relations & the Changing Contemporary

World; Nuclear Proliferation & Terrorism

RECOMMENDED BOOKS

1. Beckman, Peter, World Politics in the 20th Century, New Jersey, Prentice Hall, 1984
2. Betts, Richard K. Conflict after cold war; Arguments on causes war & Peace, New York, Macmllan Press, 1993
3. Brass, Paul. Ethnicity & Nationalism, Newbury Park, SAGE Publishers, 1992
4. Brilmayer, Lea, American Hegemony, Political Military in a one Super Power, new Heaven, CT; Yale University Press, 1994
5. Columbus, Theodore, Introduction to International Relations: Power and Justice, New Delhi: Prentice Hall, 1992.
6. Herman, Charles F, et al (eds). New Direction in the study of Foreign Policy, Boston, Allen & Unwin, 1987
7. Clinton, W.David, the two faces of National Interest, Baton Rouge, Louisiana state University Press, 1994.
8. Faue, John R hina in the World Politics, Boulder, Western Press, 1980
9. Goldstine, Josha, International Relations, Washington DC: Pearson Education, 2003.
10. Greenfeld, Liah, Nationalism: five road to modernity, Cambridge, MA: Harvard University Press, 1992

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Title of the Course: Ideology and Constitution of Pakistan
Course Code: PS-321 **Credit Hours: 02 (2+0)**

COURSE OBJECTIVE

This course is designed to provide students with the fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, 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.

LEARNING OUTCOMES

After studying the course, students will be able to:

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

COURSE OUTLINE

Understanding Ideology and Ideology of Pakistan

- Definition and significance of Ideology
- Historical context of the creation of Pakistan (with emphasis on socio-political, religious and cultural dynamics of British India between 1857 till 1947).
- Contribution of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah, etc.
- Contribution of women and students in the freedom movement for separate homeland for Muslims of British India.

Two-Nation Theory

- The Evolution of Two-Nation Theory in British India
- Urdu-Hindi Controversy
- Partition of Bengal (1905)
- Simla Deputation (1906)
- Allahabad Address (1930)
- Congress Ministries (1937-1939)
- Lahore Resolution (1940)
- Role of Communalism and Religious Differences

UNDERSTANDING CONSTITUTION AND CONSTITUTION OF PAKISTAN

- The need and importance of a constitution
- Constitutional delay in Pakistan (1947–1956)
- Ideological factors that shaped the constitution of Pakistan
- Objective Resolution (1949)
- Major Constitutional developments in Pakistan: An Overview

CONSTITUTION AND STATE STRUCTURE

- Understanding the structure of Government with reference to Pakistan
- Structure and Role of Executive
- Structure and Role of Legislators
- Structure and Role of Judiciary

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FUNDAMENTAL RIGHTS, PRINCIPLES OF POLICY AND RESPONSIBILITIES

- What are fundamental Rights under 1973 constitution of Pakistan?
- Articles 8–28 of 1973 Constitution of Pakistan
- Responsibilities of Pakistani Citizens under Article 5 of the 1973 Constitution of Pakistan

MAJOR CONSTITUTIONAL AMENDMENTS

- The need of Constitutional Amendment
- Amendment Procedure under 1973 constitution of Pakistan
- Notable Constitutional Amendments
  - ➢ Second Constitutional Amendment to 1973 Constitution
  - ➢ Seventh Constitutional Amendment to 1973 Constitution
  - ➢ Eighth Constitutional Amendment to 1973 Constitution
  - ➢ Thirteenth Constitutional Amendment to 1973 Constitution
  - ➢ Fourteenth Constitutional Amendment to 1973 Constitution
  - ➢ Seventeenth Constitutional Amendment to 1973 Constitution
  - ➢ Eighteenth Constitutional Amendment to 1973 Constitution
  - ➢ Twenty First (21st) Constitutional Amendment to 1973 Constitution

SUGGESTED BOOKS AND READING

1. Sayeed, Khalid B. *Pakistan: The Formative Phase 1857–1948*. Karachi: Oxford University Press, 1968.
2. Husain, Mahmud. *A History of the Freedom Movement: Being the Story of Muslim Struggle for the Freedom of Hind-Pakistan, 1707–1947*. Karachi: Pakistan Historical Society, 1960.
3. Qureshi, Ishtiaq Husain. *The Struggle for Pakistan*. Karachi: University of Karachi, 1965.
4. Aziz, K.K. (1976) *"Party Politics in Pakistan"*. Islamabad: National Commission on Historical and Cultural Research.
5. Mazher ul Haq. *Theory and Practice in Political Science*. Lahore: Bookland, 1996.

SEMESTER 4			
Category	Course Code	Course	Credit Hours
Major	PHY-421	Modern Physics	3 (2-1)
Major	PHY-422	Classical Mechanics	3 (3-0)
Major	MATH-426	Vector Calculus?????	3 (3-0)
Interdisciplinary	PHY-423	Environmental Physics	3 (3-0)
General Education	CS-311	Applications of Information & Communication Technologies (ICT)	3 (2-1)
General Education	MGT-411	Entrepreneurship	2 (2-0)
TOTAL CREDIT HOURS:			**17**

PHY- 421 MODERN PHYSICS

Credit Hours: Three (3)

Pre-requisites: Mechanics, Electricity and Magnetism

Objective(s): To understand the non-classical aspects of Physics, applications of Quantum Physics in micro-scale, atomic and molecular structure and processes

Course Contents:

Special Theory of Relativity: Inertial and non-inertial frame, Postulates of Relativity, The Galilean Coordinate Transformation, The Lorentz Transformation, Derivation, Assumptions on which inverse transformation is derived, Consequences of Lorentz transformation, Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity, variation of mass with velocity, mass energy relation and its importance, relativistic momentum and Relativistic energy, (Lorentz invariants) $E^2= p^2c^2+m_o^2c^4$

The Twin Paradox, The Doppler Effect for Electromagnetic Waves, Relativistic Momentum, Relativistic Work and Energy, Newtonian Mechanics and Relativity

Photons: Light Waves Behaving as Particles Historical background (from classical to modern physics), Light Absorbed as Photons: The Photoelectric Effect, Light Emitted as Photons: Production of X-rays, Measurement of the intensity of X-rays, Diffraction of X-rays and Bragg's law, single crystal X-ray spectrometer, X-ray spectrum (continuous and discrete) Moseley's law, X-ray energy level diagram, radiation less transitions, Auger effect, related problems Light Scattered as Photons: Compton Scattering and Pair Production, Wave–Particle Duality, Probability, and Uncertainty, The Uncertainty Principle, Waves and Uncertainty, Uncertainty in Energy

Particles Behaving as Waves: Electron Waves: Davisson-Germer Experiment, J. P. Thomson Experiment, The Nuclear Atom and Atomic Spectra, Rutherford's Exploration of the Atom, The Failure of Classical Physics, Energy Levels and the Bohr Model of the Atom, The Franck–

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Hertz Experiment, Hydrogen Energy Levels in the Bohr Model, Planck and the Quantum Hypothesis, The Heisenberg Uncertainty Principles for Matter

Recommended Books:

1. Robert M Eisberg, Fundamentals of Modern Physics, John Wiley & Sons 1961
2. Sanjiv Puri, Modern Physics, Narosa Publishing House, 2004.
3. Arthur Beiser, Concepts of Modern Physics (fifth edition) McGraw-Hill 1995
4. Robert M. Eisberg and Robert Resnick, Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles, 2nd edition, John Wiley & Sons, 2002.
5. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999.
6. A.P. Malvino, 'Electronic Principles', Tata McGraw Hill, New Delhi (1988).
7. Hugh D. Young, Roger A. Freedman, A. Lewis Ford, University Physics with Modern Physics, 13th Edition, Addison Wesley (2012)

PHY-421L MODERN PHYSICS

Credit Hours: One (1)

Sources of light including bulbs, light emitting diodes, laser diodes and gas lasers, experiments demonstrating optical phenomena such as interference, diffraction, linear motion, reflection, refraction, dispersion, Michelson interferometry, measurement of refractive index using interferometry, measurement of the speed of light, diffraction gratings and multiple-slit interference, thin film interference and Newton's rings, use of digital cameras for optics experiments, mode structure of lasers, use of spectrometers and monochromators, wavelength tuning of laser diodes, rainbows, emission spectroscopy of low-pressure gases (hydrogen), alkali spectra and fine structure, hyperfine structure of rubidium, vibrational spectrum of nitrogen, Lambert-Beer's law, optical polarization, magneto-optical Faraday rotation.

Recommended Books:

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

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PHY-422 CLASSICAL MECHANICS

Credit Hours: Three (3)

Pre-requisites: Mechanics

Objectives: To give a basic understanding of the classical mechanics concepts

Course Contents:

Review of Newtonian Mechanics: Frame of reference, orthogonal transformations, angular velocity and angular acceleration, Newton's laws of motion, Galilean transformation, conservation laws, systems of particles, motion under a constant force, motions under variable force, time-varying mass system.

The Lagrange Formulation of Mechanics and Hamilton Dynamics: Generalized co-ordinates and constraints, D-Alembert's principle and Lagrange's Equations, Hamilton's principle, integrals of motion, non-conservative system and generalized potential, Lagrange's multiplier method, the Hamiltonian of a dynamical system, canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.

Central Force Motion: The two-body problem, effective potential and classification of orbits, Kepler's laws, stability of circular orbits, hyperbolic orbits and Rutherford scattering, center of mass co-ordinate system, scattering cross-sections.

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

The Motion of Rigid Bodies: The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, motion of a torque-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.
3. S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; 5th ed. (2003).

Title: Vector Calculus
Course Code: MATH-426
Credit Hours: 3
Course Objectives: To develop understanding Vector Calculus and Partial Differential Equations.
Course Contents:

Analytical Geometry in 3-space, Quadratic Surfaces, Cylindrical and Spherical coordinates, Parametric representation of curves, Arc length Curvature & Torsion, Gradient of a Scalar Field and directional derivatives, Divergence of a Vector Field., Curl of a Vector Field, Line integral, integration around closed curves, Application of double integrals, Green's theorem, Surface Integrals, Triple integrals, Divergence theorem of Gauss, Stokes's theorem, Partial differential equations solvable as ODEs (separation of variables), Modeling a Vibrating String, Derivation of Wave Equation, Solution by the Method of

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Separation of Variables using Fourier Series, Heat Equation; its Solution by Fourier Series.

Recommended Books:
a. E. Kreyszing, Advanced Engineering mathematics (9th edition)
b. Swokowski, Onlinick & Pence: Calculus (6th Edition)
Reference Book: Borisenko & Taranov, Vector and Tensor Analysis with Applications.

PHY-423 ENVIRONMENTAL PHYSICS

Credit Hours: Three (3)

Objective(s): To become familiar with the essentials of environment and global climate and to learn the use of spectroscopy for environmental study.

Course Contents:

Introduction to the Essentials of Environmental Physics: The economic system, living in green house, enjoying the sun, Transport of matter, Energy and momentum, the social and political context.

Basic Environmental Spectroscopy: Black body radiation, The emission spectrum of sun, The transition electric dipole moment, The Einstein Coefficients, Lambert – Beer's law, The spectroscopy of bi-molecules, Solar UV and life, The ozone filter.

The Global Climate: The energy Balance, (Zero-dimensional Greenhouse Model), elements of weather and climate, climate variations and modeling.

Transport of Pollutants: Diffusion, flow in reverse, ground water. Flow equations of fluid Dynamics, Turbulence, Turbulence Diffusion, Gaussian plumes in air, Turbulent jets and planes.Noise: Basic Acoustics, Human Perceptions and noise criteria, reducing the transmission of sound, active control of sound. Radiation: General laws of Radiation, Natural radiation, interaction of electromagnetic radiation and plants, utilization of photo synthetically active radiation.

Atmosphere and Climate: Structure of the atmosphere, vertical profiles in the lower layers of the atmosphere, Lateral movement in the atmosphere, Atmospheric Circulation, cloud and Precipitation, The atmospheric greenhouse effect.

Topo Climates and Micro Climates: Effects of surface elements in flat and widely undulling areas, Dynamic action of Selig.

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Climatology and Measurements of Climate Factor: Data collection and organization, statistical analysis of climatic data, climatic indices, General characteristics of measuring equipment. Measurement of temperature, air humidity, surface wind velocity, Radiation balance, precipitation, Atmospheric Pressure, automatic weather stations.

Recommended Books:

1. E.T Booker and R. Van Grondelle, "Environmental Physics", John Wiley, 3rd ed. 2011.
2. G. Guyot, "Physics of Environment and Climate", John Wiley, 1998.
3. J. H. Seinfeld and S. N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. John Wiley and Sons (1998)
4. C. Smith, Environmental Physics. Environment and Politics, 2nd ed. (2001)

CS-311 Application of Information and Communication Technologies					
Credit Hours:	3 (2-3)	**Prerequisites:**	None		
Course Learning Outcomes (CLOs):					
At the end of the course the students will be able to:				**Domain**	**BT Level***
1- Explain the fundamental concepts, components, and scope of Information and Communication Technologies OCT)				C	1
2- Identify uses of various ICT platforms and tools for different purposes.				C	2
3- Apply ICT platforms and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.				C	2
4- Understand the ethical and legal considerations in use of ICT platforms and tools.				C	3
* BT = Bloom's Taxonomy, C = Cognitive domain, P = Psychomotor domain, A = Affective domain					

Course Content:

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 (Linkedln, 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.
   - ICT in Health and Well-being:
   - Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkccpcr, etc.).
   - Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).
4. ICT in Personal Financial and Shopping:
   - Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, I LINK and MNET, Keenu Wallet, etc.).
   - E-commerce platforms (Daraz.pk, Telcmart, Shophivc, etc.)
   - Digital Citizenship and Online Etiquette:
   - Digital identity and online reputation.
   - Netiquette and respectful online communication.
   - Cyberbullying and online harassment.
5. 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), and 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.

Teaching Methodology:

Lecturing, Written Assignments, Project

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Lab, Presentation, Final Exam

Reference Materials:

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.

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Course Title: Entrepreneurship
Course Code: MGT-411 **Credit Hours :02**

DESCRIPTION

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills and abilities, enabling them to seize the limited opportunities for initiating ventures and successfully navigating the challenges that come with starting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business (including requirements for registration and incorporation with regulators such as SECP and others), market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation. Overall, the course is geared towards personal growth and professional development for pursuing innovative ideas, availing opportunities and initiating start-ups.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Knowledge of fundamental entrepreneurial concepts, skills and process.
2. Understanding of different personal, social and financial aspects associatedwithentrepreneurial activities.
3. Basic understanding of regulatory requirements to set up an enterprise in Pakistan withspecial emphasis on exportbusinesses;
4. Ability to apply knowledge, skills and abilities acquired in the course to develop a feasiblebusiness plan for implementation.

COURSE 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 skills and abilities such as creative and critical thinkinginnovation and risk taking.

3. Opportunity Recognition and Idea Generation:

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

4. Marketing and Sales

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

6. 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.).

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6. Team Building for Startups:

- Characteristics and features of effective teams.
- Team building and effective leadership for startups 7. Regulatory Requirements to Establish Enterprises in Pakistan:
- Types of enterprises (e.g., sole proprietorship; partnership; private limited companiesetc.
- Intellectual property rights and protection;
- Regulatory requirements to register an enterprise in Pakistan, with special emphasisexport firms:
- Taxation and financial reporting obligation.

PRACTICAL REQUIREMENTS

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 abilities acquired in the course to develop a feasible business plan and where possible explore the possibility of implementing theplan with support and assistance from established business-persons and entrepreneurs.

SUGGESTED INSTRUCTIONAL / READING MATERIAL

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 I.can Startup: How Today's Entrepreneurs Use Continuous Innovation to CreateRadically Successful Businesses" by Eric Ries.

6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valerie Ohlsson.

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SEMESTER 5			
Category	Course Code	Course	Credit Hours
Major	PHY-511	Electronics – I	3 (2-1)
Major	PHY-512	Mathematical Methods of Physics – I	3 (3-0)
Major	PHY-513	Electromagnetic Theory	3 (3-0)
Interdisciplinary	PHY-514	Medical Physics	3 (3-0)
Interdisciplinary	PHY-515	Computational Physics	3 (2-1)
Interdisciplinary	PHY-516	Scientific Inquiry & Research Methods	3 (3-0)
TOTAL CREDIT HOURS:			**18**

PHY- 511 ELECTRONICS-I

Credit Hours: Three (3)

Pre-requisite: Modern Physics

Objectives: To give an understanding of the basic electronics

Course Contents:

The semiconductor Diode: Conductors, Insulators, and semiconductors; Silicon Crystal and Energy Band; Conduction in Silicon and Germanium; The forbidden energy gap; n and p type semiconductors; The junction diode; diode voltage-current equation; Zener diodes; Light emitting diodes; Photodiodes; Capacitance effects in the pn junction.

The Diode as Rectifier and Switch: The ideal and real diode models; The half wave rectifier; The Transformer; The full wave rectifier; The bridge rectifier; Measurement of ripple factor in the rectifier circuit; The capacitor filter; the ∏ filter; The ∏-R filter; The voltage doubling rectifier circuit; Diode wave clippers; Diode clampers.

Circuit Theory and Analysis: Basic circuit concepts; Superposition theorem; Thevenin's Theorem; Norton's Theorem; Model for circuit; one-port and two-port networks; Hybrid parameter equivalent circuit, Power in decibels.

The Junction Transistor as an Amplifier: Transistor voltage and current designations; The junction transistors; The volt-ampere curve of a transistor; The current amplification factors; The load line and Q point; The basic transistor amplifiers; The common emitter amplifier; The transconductance g_m; Performance of a CE amplifier; relation between A_i and A_v; The CB amplifier; The CC amplifier; Comparison of amplifier performance.

DC Bias for the Transistor: Choice of Q point, variation of Q point, fixed transistor bias, the four resistor bias circuit, design of a voltage –feedback bias circuit, Common emitter, common collector, common base biasing

Field Effect Transistor: Field effect transistor (JFET); Static characteristics of JFET, Metal oxide semiconductor Field Effect Transistor (MOSFET of IGFET); Enhancement and

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depletion mode; FET biasing techniques; Common drain; common source and common gate; Fixed bias and self-bias configurations; Universal JFET bias curve; Darlington pair.

Operational Amplifiers: The integrated amplifier; The differential amplifier; Common mode rejection ratio; The operational amplifier; Summing operation; Integration operation; Comparator; milli-voltmeter.

Recommended Books:

1. J.D. Ryder, "Electronic Circuits and Systems", Prentice Hall (1976).
2. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. (2009).
3. Theodore F. Bogart, "Electric Circuits", McGraw Hill, (1992)
4. B. Grob, "Basic Electronics", MacGraw Hill, Tch ed. (1997).
5. A. P. Malvino, "Electronic Principles", McGraw Hill, 7th ed. (2006).
6. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, (1998)

PHY-511L ELECTRONICS

Credit Hours: One (1)

DC voltages and current measurement, simple DC circuits, generating and analyzing time-varying signals, op-amps and comparators, amplifier design, RC transients, filters, frequency response, LC circuits, resonance, transformers, diodes, modulation and radio reception, MOSFET characteristics and applications, principles of amplification, bipolar transistors and amplifiers, digital logic circuits, gates and latches, D-flip flops and shift registers, JK flip-flops and ripple counters.

Recommended Books:

1. C. Melissinos and J. Napolitano, "Experiments in Modern Physics", Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, "An Introduction to Uncertainty in Measurement", Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001)

PHY-512 MATHEMATICAL METHODS OF PHYSICS-I

Credit Hours: Three (3)

Pre-requisite: Mechanics, Differential Equations, Linear Algebra

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Objective(s): To develop the mathematical background of student in vectors, tensors, matrices and some of their uses in the world of physics, to give basic understanding of group theory and complex variables used in physics.

Course Contents:

Vector Analysis: Review of vectors Algebra, Vector operations, Physical significance of DEL operator, Line integrals, Surface and Volume Integrals, Gradient of a scalar, Divergence of a vector, Directional derivatives and gradients, Curl of a vector, Gauss's divergence theorem, Green's theorem, Vector differentiation and gradient, Vector integration, , Stokes's Curl theorem, Cartesian coordinates systems, Polar coordinates systems, Spherical polar and Cylindrical coordinates systems.

Matrices: Determinants, Matrices, Linear vector spaces, orthogonal matrices, Hermitian matrices, Unitary Matrices, Orthogonalization, Eigenvalues and eigenvectors of matrices, , Similarity transformations, Diagonalization of matrices.

Complex Variables: Complex numbers , Functions of a complex variable, analytic functions of complex variables, De Moivre's theorem, Taylor and Laurent series, Cauchy Riemann conditions and analytic functions, Cauchy integral theorem, Cauchy integral formula, Euler's formula, harmonic functions, complex integration, Contour integrals, singularities and residues, residue theorem.

Recommended Books:

1. G. Arfken, Mathematical Physics, 2nd ed, Academic Press, 1970.
2. Dass H.K, R. Verma, 2011, 6th Edition, Mathematical Physics, S. Chand& Company Ltd. New Delhi.
3. E. Butkov, Mathematical Physics, Addison-Wesley 1968.
4. Pipes and Harvill, Applied Mathematics for Engineers and Physicists, McGraw Hill, 1971.
5. M. L. Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons, New York (1989).
6. M. R. Speigel, Complex Variables Schaum's Outline Series, McGraw Hill 1979.

PHY-513 ELECTROMAGNETIC THEORY

Credit Hours: Three (3)

Pre-requisites: Electricity and Magnetism, Calculus-II

Objective(s): This course provides a unified framework for understanding the fundamental concepts of classical electromagnetic theory. It covers electrostatics, magnetostatics, Maxwell's equations, electromagnetic wave propagation, and an introduction to electromagnetic radiation and relativistic electrodynamics.

Course Contents:

Vector Calculus and Dirac Delta Function: Review of vector algebra and calculus; gradient, divergence, and curl; Cartesian and spherical coordinates; Dirac delta function; divergence of $\mathbf{r}/r^2$; Helmholtz theorem.

Electrostatics: Electric field due to point and continuous charge distributions; Coulomb's law; Gauss's law and its applications; divergence and curl of **E**; electric potential, Poisson's and Laplace's equations; electrostatic boundary conditions; work and energy in electrostatics; conductors and capacitors.

Electric Fields in Matter: Dielectrics and polarization; bound charges; electric displacement field **D**; Gauss's law in dielectrics; boundary conditions; linear dielectrics; energy in dielectric systems.

Magnetostatics: Lorentz force law; Biot–Savart law; magnetic field of steady currents; Ampère's law; divergence and curl of **B**; magnetic vector potential.

Magnetic Fields in Matter: Magnetization; bound currents; auxiliary magnetic field **H**; magnetic boundary conditions; magnetic susceptibility and permeability; diamagnetic, paramagnetic, and ferromagnetic materials.

Electrodynamics and Maxwell's Equations: Electromotive force (emf); Faraday's law of induction; motional emf; Maxwell's correction to Ampère's law; complete set of Maxwell's equations in vacuum and in matter; boundary conditions.

Conservation Laws: Continuity equation; Poynting's theorem; energy and momentum in electromagnetic fields; Maxwell's stress tensor; conservation of angular momentum.

Electromagnetic Waves: Wave equation in vacuum and matter; plane waves; polarization; energy and momentum of waves; reflection and transmission at normal and oblique incidence; wave propagation in conductors; skin depth.

Potentials and Radiation (Introductory): Scalar and vector potentials; gauge transformations; retarded potentials; Liénard–Wiechert potentials (conceptual); dipole radiation and radiation from point charges (qualitative).

Electrodynamics and Special Relativity (Introductory): Einstein's postulates; Lorentz transformations; relativistic energy and momentum; magnetism as a relativistic effect; transformation of electric and magnetic fields; covariant form of Maxwell's equations (conceptual overview).

Recommended Books:

1. D. J. Griffiths, *Introduction to Electrodynamics*, Prentice Hall, 3rd ed. (1999)
2. M. N. O. Sadiku, *Elements of Electromagnetics*, Oxford University Press, 5th ed. (2009)
3. F. Melia, *Electrodynamics*, University of Chicago Press, 1st ed. (2001)

Head
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4. J. Hearld & W. Müller-Kirsten, *Electrodynamics*, World Scientific Publishing, 2nd ed. (2011)

PHY-514 MEDICAL PHYSICS

Credit Hours: Three (3)

Objective(s): To introduce the fundamental physical principles and instrumentation used in medical diagnosis and therapy. The course emphasizes the application of physics in medical imaging, radiation therapy, and health technologies, providing students with an understanding of the role of physics in modern medicine.

Course Contents:

Introduction to Medical Physics: Role of physics in medicine; overview of diagnostic and therapeutic techniques; units and standards in medical applications; biological effects of radiation.

Radiation Physics: Types of radiation; interaction of ionizing radiation with matter; linear energy transfer (LET); stopping power; attenuation and absorption; radiation dosimetry.

Radiation Detection and Measurement: Gas-filled detectors; scintillation detectors; semiconductor detectors; dose calibrators; thermoluminescent dosimeters (TLDs); survey meters.

Diagnostic Radiology: X-ray production; X-ray tubes; radiographic image formation; contrast agents; computed tomography (CT); digital radiography; image quality and safety.

Nuclear Medicine: Radioisotopes in medicine; gamma cameras; SPECT and PET imaging; radiopharmaceuticals; radiation protection in nuclear medicine.

Magnetic Resonance Imaging (MRI): Basic principles of nuclear magnetic resonance (NMR); tissue contrast mechanisms; MRI instrumentation; image acquisition; safety considerations.; **Ultrasound Imaging**

Generation and propagation of ultrasound; acoustic impedance; reflection and transmission; transducers; Doppler imaging; applications and limitations.

Radiation Therapy: External beam radiotherapy (EBRT); linear accelerators; brachytherapy; treatment planning systems; dose distribution; radiobiology principles.

Health Physics and Radiation Protection: Radiation hazards; exposure limits; shielding methods; regulatory bodies and safety standards; personal protective equipment (PPE); emergency procedures.

Recent Advances in Medical Physics: Emerging technologies in diagnostic and therapeutic physics; image-guided therapy; artificial intelligence in medical imaging; nanotechnology in medicine.

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Recommended Books:

1. Hendee & Ritenour, Medical Imaging Physics, Wiley-Liss, 4th Ed. (2002)
2. R. G. Lerner & G. L. Trigg, Encyclopedia of Physics, VCH Publishers
3. S. Webb, The Physics of Medical Imaging, IOP Publishing (1992)
4. J. T. Bushberg et al., The Essential Physics of Medical Imaging, Lippincott Williams & Wilkins, 3rd Ed (2011)
5. P. Sprawls, Physical Principles of Medical Imaging, Aspen Publishers (1987)

PHY-515 COMPUTATIONAL PHYSICS

Credit Hours: Three (3)

Objective(s): Introduction of computer languages to know the use of computer in numerical analysis, Computer simulation and modeling

Course Contents:

Computer Languages: A brief introduction of the computer languages like Basic, C. Pascal etc and known software packages of computation

Numerical Methods: Numerical Solutions of equations, Regression and interpolation, Numerical integration and differentiation. Error analysis and technique for elimination of systematic and random errors

Modeling & Simulations: Conceptual models, the mathematical models, Random numbers and random walk, Doing Physics with random numbers, Computer simulation, Relationship of modeling and simulation. Some systems of interest for physicists such as Motion of Falling objects, Kepler's problems, Oscillatory motion, Many particle systems, Dynamic systems, Wave phenomena, Field of static charges and current, Diffusion, Populations genetics etc.

Recommended Books:

1. M. L. De Jong,"Introduction to Computational Physics", Addison Wesley, (1991).
2. S. T. Koonini, "Computational Physics", the Benjamin-Cummings, (1985).
3. H. Gould, J. Tobochnik and W. Christian, "An Introduction to Computer Simulation Methods", Addison Wesley, 3rd ed. (2006).
4. S. C. Chapra and R. P. Chanle," Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill, (1990).
5. S. C. Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", McGraw Hill, 2nd ed. (2006).

PHY-516 SCIENTIFIC INQUIRY & RESEARCH METHODS

Credit Hours: Three (3)

Objective(s): To equip students with essential skills in scientific thinking, research methodology, data analysis, and academic writing. The course aims to develop the ability to critically evaluate scientific literature, design research projects, and effectively communicate scientific findings.

Course Contents:

Introduction to Scientific Inquiry: Nature of science; scientific method; hypothesis formulation; theory and law in science; ethics in research.

Research Design and Methodology: Qualitative and quantitative research; experimental and non-experimental designs; variables, sampling techniques, controls, and bias; validity and reliability.

Literature Review and Referencing: Sources of scientific literature; strategies for conducting effective literature reviews; plagiarism and academic integrity; citation styles (APA, IEEE, etc.); use of reference management tools (e.g., Zotero, Mendeley).

Scientific Writing and Communication: Structure of scientific papers (IMRAD format); writing abstracts, introductions, and conclusions; graphical representation of data; preparation of research proposals and reports; poster and oral presentations.

Data Collection and Analysis: Types of data; techniques for data collection (surveys, interviews, observations, experiments); descriptive and inferential statistics; use of software tools (e.g., Excel, SPSS, Origin, MATLAB) for data analysis.

Critical Thinking and Problem Solving: Analytical reasoning; logical argumentation; identifying fallacies; evaluating scientific claims and research findings.

Research Ethics and Integrity: Principles of ethical research; informed consent; confidentiality; role of institutional review boards (IRBs); misconduct in research and its consequences.

Scientific Collaboration and Project Management: Working in research teams; collaborative tools and platforms; time and resource management; writing funding proposals; introduction to research funding agencies.

Recommended Books:

1. C. R. Kothari & G. Garg, Research Methodology: Methods and Techniques, New Age International Publishers, 4th Ed. (2019)
2. Wayne C. Booth et al., The Craft of Research, University of Chicago Press, 4th Ed. (2016)
3. Deborah Rumsey, Statistics for Dummies, Wiley Publishing, 2nd Ed. (2011)
4. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications, 5th Ed. (2022)
5. Michael Alley, The Craft of Scientific Writing, Springer, 4th Ed. (2018)

SEMESTER 6			
Category	Course Code	Course	Credit Hours
Major	PHY-521	Electronics – II	3 (2-1)
Major	PHY-522	Quantum Mechanics – I	3 (3-0)
Major	PHY-523	Mathematical Methods of Physics – II	3 (3-0)
Major	PHY-524	Electrodynamics & Special Relativity	3 (3-0)
Major	PHY-525	Condensed Matter Physics	3 (3-0)
TOTAL CREDIT HOURS			15

PHY-521 ELECTRONICS-II

Credit Hours: Three (3)

Pre-requisites: Electronics-I

Objective(s): To enhance the understanding of electronic circuits and key electronic components such as amplifiers, oscillators etc. for applications in telecommunication systems

Course Contents:

Amplifiers and their Frequency Response: Cascade amplifier, pass band, frequency plots, low and high frequency limits, un-bypassed emitter resistor, Miller effect, transistor high-frequency response, and bandwidth of cascade amplifiers.

Feedback Principles of positive/negative feedback, gain stabilization, bandwidth improvement, distortion reduction, and feedback circuit types (current series, voltage shunt).

Oscillators: Classification, damped/undamped oscillations, frequency stability, essentials of LC oscillators, Hartley, Colpitts, crystal oscillators.

Power Amplifiers: Class-A and Class-B amplifiers, efficiency, output distortion, and thermal effects.

Modulation and Demodulation: Need for modulation, AM and SSB systems, diode detectors, AVC, FM principles, and radio applications.

Multivibrators: Astable, mono-stable, bi-stable multivibrators, Schmitt trigger, and applications.

Integrated Circuits: Advantages/limitations, scale and function-based classification, fabrication steps (wafer prep, diffusion, oxidation, lithography, deposition, metallization, packaging).

Digital Circuits: Number systems (decimal, binary, octal, hex), conversions, binary codes, logic gates, Boolean algebra, SOP/POS simplification.

Head
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Recommended Books:

1. T. L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. (2009).
2. B. Grob, "Basic Electronics", MacGraw Hill, Tch ed. (1997).
3. B. Streetman and S. Banerjee "Solid State Electronics Devices", Prentice Hall, 6th ed. (2005).
4. Bar-lev, "Semiconductor and Electronics Devices", Prentice Hall, 3rd ed. 1993.
5. D. H. Navon and B. Hilbert, "Semiconductor Microdevices and Materials", CBS College Publishing, (1986).
6. P. Malvino, "Electronic Principles", McGraw Hill, 7th ed. (2006).
7. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, (1998).

PHY-521L ELECTRONICS

Credit Hours: One (1)

Electronics: DC voltages and current measurement, simple DC circuits, generating and analyzing time-varying signals, opamps and comparators, amplifier design, RC transients, filters, frequency response, LC circuits, resonance, transformers, diodes, modulation and radio reception, MOSFET characteristics and applications, principles of amplification, bipolar transistors and amplifiers, digital logic circuits, gates and latches, D-flip flops and shift registers, JK flip-flops and ripple counters.

PHY- 522 QUANTUM MECHANICS-I

Credit Hours: Three (3)

Pre-requisites: Modern Physics

Objectives: To give a basic understanding of the quantum mechanics

Course Contents:

Waves and Particles: Basic ideas of quantum mechanics, electromagnetic waves and photons, matter particles and matter waves, quantum description of particles, wave packets, motion in time-independent potentials, uncertainty relations, Gaussian wave packets, spreading, particle in a square potential, and behavior at potential steps.

Mathematical Tools: Wave function and state space, Dirac notation, representations, observables, linear and unitary operators, commutation relations, position and momentum operators, and applications such as the two-dimensional infinite well.

Postulates of Quantum Mechanics: Statements and interpretation, Schrödinger equation and its implications, superposition principle, infinite potential well, probability current, conjugate

Head
Department of Physics
Bacha Khan University
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observables, density and evolution operators, Schrödinger and Heisenberg pictures, gauge invariance, bound and unbound states in arbitrary potentials, and periodic structures.

Applications to Simple Systems (Spin ½ and Two-Level Systems): Spin ½ particles, angular momentum quantization, Pauli matrices, diagonalization of Hermitian matrices, two-level quantum systems, density matrix, coupled spin systems, spin in static and rotating fields, and magnetic resonance phenomena.

The Harmonic Oscillator: Significance in physics, eigenvalues and eigenstates, Hermite polynomials, stationary states, 3D isotropic oscillator, charged oscillator in electric fields, coherent states, coupled oscillators, vibrational modes, phonons, and oscillator in thermal equilibrium.

Angular Momentum: General properties, commutation relations, orbital angular momentum, spherical harmonics, rotation operators, diatomic molecules, angular momentum in oscillators, charged particles in magnetic fields, and Landau levels.

Particle in a Central Potential: Hydrogen atom, stationary states, center-of-mass and relative motion in two-body systems, hydrogen-like systems, isotropic harmonic oscillator, probability currents, magnetic field effects, Zeeman effect, atomic orbitals, and vibrational-rotational levels of diatomic molecules.

Recommended Books:

1. D. J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. (2004).
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. (2002).
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. (2009).

PHY-523 MATHEMATICAL METHODS OF PHYSICS-II

Credit Hours: Three (3)

Pre-requisite: Mathematical Methods of Physics-I

Objective(s): To give the understanding of Differential equations and their uses in Physics, Introduction to special functions, Fourier Series, Fourier Transforms, Solution of Boundary value problems and their uses.

Course Contents:

Special Functions: Gamma functions, Beta functions, Bessel functions, generating function, recurrence relation, Spherical Bessel functions, Legendre polynomials, Associated Legendre polynomials, Hermite polynomials.

Fourier series: Definition and general properties, Fourier series of various physical functions, complex form of Fourier series, uses and application of Fourier series, Parseval's theorem

Head
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Bacha Khan University
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Integral Transforms: Integral transform, Fourier transform, Fourier cosine transform,Fourier sine transform, Convolution theorem, Elementary Laplace transform and its applications, Fourier transform of derivatives, Inverse Laplace Transform, Laplace transform of derivatives. Physical significance along with examples of Fourier and Laplace transforms, Integral transform solution of partial differential equations,

Differential Equations in Physics: First and second order linear differential equations, Partial differential equations of theoretical physics, Separation of variables, Homogeneous differential equations, Frobenius series solution of differential equations, Nonhomogeneous differential equations. Applications of partial differential equations

Recommended Books

1. G. Arfken, Mathematical Physics, 2nd ed, Academic Press, 1970.
2. Dass H.K, R. Verma, 2011, 6th Edition, Mathematical Physics, S. Chand& Company Ltd. New Delhi.
3. E. Butkov, Mathematical Physics, Addison-Wesley 1968.
4. Pipes and Harvill, Applied Mathematics for Engineers and Physicists, McGraw Hill, 1971.
5. M. L. Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons, New York (1989)
6. M. R. Speigel, Complex Variables Schaum's Outline Series, McGraw Hill 1979

PHY-524 ELECTRODYNAMICS & SPECIAL RELATIVITY

Credit Hours: Three (3)

Pre-requisites: Electricity & Magnetism, Calculus-II, Vector Analysis

Objectives: This course introduces students to the unified framework of classical electrodynamics and the special theory of relativity. It develops understanding from static electric and magnetic fields to wave propagation and radiation, and it explains how Maxwell's theory and Einstein's postulates transform our understanding of space, time, and energy.

Course Contents:

Vector Calculus Review: Vector algebra and calculus, Dirac delta function, divergence and curl, coordinate systems, Helmholtz theorem.

Electrostatics: Coulomb's law, Electric field from continuous charge distributions, Gauss's law, Electric potential, Poisson's and Laplace's equations. Boundary value problems, method of images, basic multipole expansion. Work and energy in electrostatics. Conductors and capacitors.

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Electric Fields in Matter: Polarization, bound charges, electric displacement field D, Gauss's law in dielectrics, boundary conditions, linear dielectrics.

Magnetostatics: Lorentz force law, Biot–Savart law, Ampere's law, magnetic vector potential, divergence and curl of B, magnetic boundary conditions.

Magnetic Materials: Magnetization, bound currents, auxiliary field H, susceptibility and permeability, boundary conditions.

Maxwell's Equations and Electrodynamics: Faraday's law, motional emf, Maxwell's equations in vacuum and matter, displacement current, boundary conditions.

Electromagnetic Waves: Wave equation in vacuum, plane waves, energy and momentum of EM waves, polarization, reflection and transmission at normal incidence.

Potentials and Radiation: Scalar and vector potentials, gauge freedom, retarded potentials, dipole radiation, Liénard–Wiechert potentials (conceptual only).

Special Theory of Relativity: Einstein's postulates, Lorentz transformations, time dilation, length contraction, simultaneity, Minkowski space. Relativistic energy and momentum, mass–energy equivalence, four-vectors, Doppler effect, twin paradox.

Recommended Books:

1. D. J. Griffiths, Introduction to Electrodynamics, Prentice Hall, 3rd ed. 1999
2. Resnick, Introduction to Special Relativity, Wiley
3. French, A.P., Special Relativity, Norton
4. M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Press
5. Einstein, Relativity: The Special and the General Theory, Random House

PHY-525 CONDENSED MATTER PHYSICS

Credit Hours: Three (3)

Pre-requisites: Quantum Mechanics, Statistical Mechanics, Electromagnetism

Objectives: The course aims to provide students with a foundational understanding of the physical principles governing the behavior of solids. It emphasizes the quantum and statistical origins of electronic, magnetic, and optical properties of materials. Students will explore both classical and modern models to describe the structure, dynamics, and transport phenomena in crystalline solids, including an introduction to emerging materials such as superconductors and soft matter systems.

Course Contents:

Crystal Structure: Amorphous and crystalline solids. Unit cells, crystal systems, Bravais lattices. Miller indices, symmetry operations. Common crystal structures: FCC, BCC, HCP. Crystal planes and directions.

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Reciprocal Lattice and Diffraction: Reciprocal lattice and its construction. Brillouin zones. X-ray diffraction and Bragg's law. Laue and powder diffraction methods. Structure factor and atomic form factor.

Lattice Vibrations and Phonons: One-dimensional monoatomic and diatomic chains. Vibrational modes and dispersion relations. Quantization of lattice vibrations: phonons. Heat capacity models: Einstein and Debye models. Thermal conductivity and phonon scattering.

Free Electron Theory of Metals: Drude model of electrical and thermal conductivity. Limitations of classical models. Sommerfeld model: free electron Fermi gas, density of states, Fermi energy, and heat capacity. Electrical conductivity and Wiedemann-Franz law.

Band Theory of Solids: Bloch's theorem. Nearly-free electron model. Formation of energy bands and band gaps. Tight-binding model. Concept of Brillouin zones. Effective mass. Distinction between metals, semiconductors, and insulators.

Semiconductors: Intrinsic and extrinsic semiconductors. Carrier concentration and Fermi level. Electrical conductivity and temperature dependence. p–n junction, basic semiconductor devices.

Magnetism in Solids: Origin of magnetic moments, types of magnetism: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism. Langevin theory. Curie and Curie-Weiss laws. Magnetic domains and hysteresis.

Dielectric and Optical Properties: Polarization mechanisms, dielectric constant, local field effects. Frequency dependence of dielectric response. Optical absorption and dispersion. Excitons, plasmons, polaritons. Optical properties of semiconductors.

Superconductivity: Basic properties: zero resistivity, Meissner effect. Type I and II superconductors. London equations. Introduction to BCS theory. Applications of superconductors.

Introduction to Soft Condensed Matter (Optional Topic): Basic concepts of polymers, liquid crystals, colloids. Physical behavior and applications in modern materials science.

Recommended Books:

1. Kittel, Introduction to Solid State Physics, Wiley
2. Ashcroft & Mermin, Solid State Physics, Cengage
3. Marder, Condensed Matter Physics, Wiley
4. Omar, Elementary Solid State Physics, Pearson
5. Hook & Hall, Solid State Physics, CRC Press

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SEMESTER 7			
Category	Course Code	Course	Credit Hours
Major	PHY-611	Atomic & Molecular Physics	3 (2-1)
Major	PHY-612	Quantum Mechanics – II	3 (3-0)
Major	PHY-613	Nuclear Physics	3 (2-1)
Major	PHY-	Elective – I	3
Major	PHY-	Elective – II	3
Major	PHY-698	Internship	3
TOTAL CREDIT HOURS:			**18**

PHY- 611 **ATOMIC AND MOLECULAR PHYSICS**

Credit Hours: **Three (3)**

Pre-requisites: **Quantum Mechanics I**

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

Course Contents:

Structure of Atoms: Review of Bohr's theory, Sommerfeld Model, Frank Hertz experiment and approximation methods.

One Electron System: Review of Schrodinger equation for hydrogen atom, Fermi Golden rule, Quantum numbers, Atoms in radiation field, Radiative transitions, Einstein coefficients, Selection rules, normal Zeeman effect, Stark effect, Hyperfine structure.

Many body Systems: Pauli exclusion principle, Periodic system of the elements, Stern-Gerlach experiment, Spin orbit coupling, Central field approximation, Hartree Fock methods and self consistent field, Thomas Fermi potential, LS coupling, jj coupling and other types of coupling, X-ray spectra.

Interaction with field: Many electron atoms in an electromagnetic field, Anomalous Zeeman effect, Paschen back effect, Stark effect.

Molecules: Ionic and covalent bonding, Diatomic molecules, rotational, vibrational and electronic spectra; Born Oppenheimer approximation, Transition probabilities of diatomic molecules, electron spin and Hund's cases, Polyatomic molecules (brief introduction), Raman effect, Hydrogen Molecular ion (LCAO approximation), Hydrogen molecule (Heitler London and molecular orbital theories)

Recommended Books:

1. B. H. Bransden and C. J. Joachain, "Physics of Atoms and Molecules", Pearson Education, 2nd ed. (2008).
2. C. J. Foot, "Atomic Physics", Oxford University Press, (2005).

3. Anne P. Thorne, Spectrophysics, Chapman and Hall, 2nd ed. (1988).
4. W. Demtroder, "Atoms, Molecules and Photons", y, Springer, 2nd ed. (2010).
5. C. N. Banwell and E. M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4th ed. (1994).
6. J. M. Hollas, "Basic Atomic & Molecular Spectroscopy", John Wiley, 2002.

PHY-611L MODERN PHYSICS

Credit Hours: One (1)

1. Photoelectric effect,
2. Frank- Hertz's quantization of energy levels,
3. Determination of Planck's constant (e.g. using a light bulb),
4. Verification of Moseley's law using X-ray fluorescence,
5. Compton effect
6. Millikan's experiment for determination of charge of electron
7. Measurement of electrical conductivity by two-probe and four-probe methods, band gap estimation of intrinsic and extrinsic semiconductors, carrier lifetimes and mobilities, Hall effect and its application in measuring magnetic fields, thermoelectric effects

PHY- 612 QUANTUM MECHANICS-II

Credit Hours: Three (3)

Pre-requisites: Quantum Mechanics-I

Objective(s): This course is aimed at bridging the classical concepts with quantum mechanical concepts and will lead to the second part of the core level undergraduate course on quantum mechanics

Course Contents:

Addition of Angular Momenta: Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, addition of spherical harmonics, vector operators, Wigner-Eckart theorem, electric Multipole moments, Evolution of two angular momenta J_1 and J_2 coupled by an interaction "$aJ_1 . J_2$".

Stationary Perturbation Theory: Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level, one-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces, volume effect and the influence of spatial extension of the

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nucleus on the atomic levels, variational method, energy bands of electrons in solids, a simple example of the chemical bond: The H_2^+ ion

Applications of Perturbation Theory to Atomic Systems: Fine and hyperfine structure of atomic levels in hydrogen, Calculation of the mean values of the spin-orbit coupling in the 1*s*, 2*s* and 2*p* levels, hyperfine structure and the Zeeman effect for muonium and positronium, Stark effect

Approximation Methods for Time-Dependent Problems: Statement of the problem, approximate solution of the Schrodinger equation, An important special case: Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation, Oscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule

Systems of Identical Particles: Identical particles, Permutation operators, Symmetrization postulate, difference between bosons and fermions, Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom, configurations, terms, multiplets, spin isomers of hydrogen (ortho- and para-hydrogen)

Scattering by a Potential: Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential, method of partial waves, phenomenological description of collisions with absorption.

Recommended Books:

1. D. J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. (2004).
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. (2002).
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. (2009).

PHY- 613 NUCLEAR PHYSICS

Credit Hours: Three (3)

Pre-Requisites: Modern Physics

Objective(s): To understand the nuclear structure using different nuclear models, the nature of nuclear forces, radioactivity and nuclear reactions

Course Contents:

Basic Properties of Nucleus: Nuclear size; mass; binding energy; nuclear spin; magnetic dipole and electric quadrupole moment; parity and statistics

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Nuclear Forces: Yukawa's theory of nuclear forces; Nucleon scattering; charge independence and spin dependence of nuclear force; isotopic spin

Nuclear Models: Liquid drop model; Fermi gas model; Shell model; Collective model

Theories of Radioactive Decay: Theory of Alpha decay and explanation of observed phenomena; measurement of Beta ray energies; the magnetic lens spectrometer; Fermi theory of Beta decay; Neutrino hypothesis; theory of Gamma decay; multipolarity of Gamma rays; Nuclear isomerism

Accelerators and detectors: Van de Graph generator; linear accelerator; cyclotron; magnetron; Geiger-Muller counter; bubble chamber; cloud chamber; scintillator.

Nuclear Reactions: Conservation laws in nuclear reactions; Q-value and threshold energy of nuclear reaction; energy level and level width; cross sections for nuclear reactions; compound nucleolus theory of nuclear reaction and its limitations; direct reaction; resonance reactions; Breit-Wigner one level formula including the effect of angular momentum.

Recommended Books:

1. E. Segre, "Nuclei and Particles", Benjamin-Cummings, 2nd ed. (1977).
2. Kaplan, "Nuclear Physics", Addison-Wisely, (1980).
3. Green, "Nuclear Physics", McGraw Hill, 1954.
4. K. S. Krane, "Introducing Nuclear Physics", John Wiley, 3rd ed. (1988).
5. B. Povh, K. Rith, C. Scholtz, F. Zetsche, "Particle and Nuclei", (1999).

PHY- 613L LAB NUCLEAR PHYSICS

Credit Hours: One (1)

1. Study and calibration of Geiger-Müller (GM) counter
2. Verification of the inverse square law for gamma radiation
3. Measurement of background radiation and statistical nature of decay
4. Determination of half-life of a radioactive source
5. Absorption of beta and gamma radiation in different materials
6. Study of energy spectrum using a scintillation detector
7. Use of multichannel analyzer (MCA) in nuclear spectroscopy
8. Efficiency and energy calibration of detectors
9. Study of shielding and radiation protection techniques
10. Basic safety procedures in handling radioactive sources

Recommended Books:

1. G. F. Knoll, *Radiation Detection and Measurement*, Wiley, 4th Ed. (2010)
2. S. B. Patel, *Nuclear Physics: An Introduction*, New Age International Publishers (2011)
3. J. C. Blewitt, *Nuclear Physics Laboratory Manual*, D. Van Nostrand

SEMESTER 8			
Category	Course Code	Course	Credit Hours
Major	PHY-621	Statistical Mechanics	3 (3-0)
Major	PHY-	Elective – III	3
Major	PHY-	Elective – IV	3
Interdisciplinary	PHY-622	Artificial Intelligence in Physics	3 (2-1)
Capstone	PHY-699	Capstone	3
TOTAL CREDIT HOURS:			**15**

PHY- 621 STATISTICAL PHYSICS

Credit Hours: Three (3)

Pre-requisites: Heat and Thermodynamics

Objective: The main objective is to develop an understanding of the physical properties of the matter "in Bulk", on the basis of the Dynamic behaviour of its microscopic constituents.

Course Contents:

Review of Classical Thermodynamics: Review of Thermodynamic Potentials; Chemical Potential; Phase Equilibria; Maxwell Relations

Foundations of Statistical Mechanics: Phase Space; Trajectories in Phase Space; Conserved Quantities and Accessible Phase Space; Macroscopic Measurements and Time Averages; Ensembles and Averages over Phase Space; Liouville's Theorem; The Ergodic Hypothesis; Equal a priori Probabilities; Specification of the state of a system; concept of ensembles; elementary probability calculations; distribution functions; statistical interpretation of entropy (Boltzmann theorem)

Statistical Ensembles: Phase Space; Specification of the State of a System; Statistical Ensembles; Probability Calculations and Density of States; Micro-canonical ensemble; canonical ensemble and examples (e.g., paramagnet); calculation of mean values; calculation of partition function and its relation with thermodynamic quantities; the grand canonical ensemble and examples (e.g. adsorption); calculation of partition function and thermodynamic quantities

Simple Applications of Ensemble Theory: Monoatomic ideal gas in classical and quantum limit; Gibb's paradox and quantum mechanical enumeration of states; equipartition theorem and examples (ideal gas, harmonic oscillator); specific heat of solids; quantum mechanical calculation of paramagnetism

Quantum Statistics: Indistinguishability and symmetry requirements; Maxwell-Boltzmann statistics; Bose-Einstein and photon statistics; Fermi-Dirac statistics (distribution functions,

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partition functions); Examples: polyatomic ideal gas (MB), black body radiation (photon statistics), conduction electrons in metals (FD), Bose condensation (BE)

Recommended Books:

1. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Pr Inc, (2008).
2. W. Brewer, F. Schwabl, "Statistical Mechanics", Springer, 2nd ed. (2006).
3. T. L. Hill, "Statistical Mechanics", World Scientific Publishing Company, (2004).
4. K. Huang, "Statistical Mechanics", John Wiley, 2nd ed. (1987).
5. J. Pointon, "Introduction to Statistical Physics", Longman (1967).

PHY-622 ARTIFICIAL INTELLIGENCE IN PHYSICS

Credit Hours: Three (3)

Pre-requisites: Programming Fundamentals, Calculus, Introductory Physics, Basic Linear Algebra

Objectives The course introduces fundamental concepts of Artificial Intelligence (AI), with a focus on their applications in solving physical problems. Students will learn core AI techniques—including machine learning, data-driven modeling, and neural networks—and apply them to areas such as computational physics, data analysis, and experimental automation. Emphasis is placed on real-world problem-solving using simulations, pattern recognition, and modeling physical systems.

Course Contents:

Introduction to Artificial Intelligence: Definition and scope of AI. Applications of AI in science and engineering. AI vs traditional programming. Overview of AI techniques used in physical sciences.

Python for Scientific Computing: Python basics, NumPy, Matplotlib, and SciPy. Introduction to Jupyter Notebooks. Data handling and visualization with Pandas.

Introduction to Machine Learning: Supervised vs. unsupervised learning. Training, testing, and validation. Overview of tools: Scikit-learn and TensorFlow. Data preprocessing and feature engineering.

Regression and Classification: Linear and polynomial regression for experimental data. Logistic regression for binary classification. Application to curve fitting and experimental modeling.

Clustering and Dimensionality Reduction: K-means clustering, Principal Component Analysis (PCA). Applications to high-dimensional physical data sets (e.g., spectroscopy, particle data).

Artificial Neural Networks (ANNs): Structure and training of neural networks. Activation functions, loss functions, backpropagation. Application to pattern recognition in physics experiments (e.g., signal identification).

Deep Learning and Physics-Informed Neural Networks (PINNs): Basics of deep learning and convolutional neural networks (CNNs). Introduction to Physics-Informed Neural Networks for solving differential equations and modeling dynamical systems.

AI Applications in Experimental Physics: Noise filtering in sensor data. Automated image and signal classification (e.g., atomic force microscopy, cosmic ray detection). Robotics and control systems.

AI in Theoretical and Computational Physics: Data-driven simulations of physical systems. Predictive modeling of physical phenomena. Using ML to accelerate Monte Carlo simulations and numerical solvers.

Ethical and Practical Considerations: Bias, interpretability, and explainability in AI. Limitations and uncertainties in AI models. Reproducibility and open science in AI applications.

Recommended Books:

1. V. Dhar, Data Science and Machine Learning: Building AI Applications, Wiley
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow
3. C. M. Bishop, Pattern Recognition and Machine Learning, Springer
4. Mehta et al., A High-Bias, Low-Variance Introduction to Machine Learning for Physicists *(arXiv)*
5. Python official documentation, Scikit-learn, TensorFlow guides
6. Selected research papers and case studies in AI applications to physics

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ELECTIVE COURSES IN BS PHYSICS

These elective courses can be chosen from the list according to the availability of the staff and necessary infrastructure.

PHY-623 FLUID MECHANICS

Credit Hours: Three (3)

Pre-requisites: Classical Mechanics

Objectives: The main objective of this course is to make students familiar with the concepts of fluid flows. This course provides a theoretical foundation for ideal and real fluid flows. This fundamental course will provide sufficient knowledge to enable students to understand, model and solve basic practical flow problems

Course Contents:

Basic Concepts: Fluid properties-viscosity, the microscopic and macroscopic view of fluid, incompressible and compressible fluids; circulation; elementary fluid kinematics; velocity field; substantial derivative; streamlines and path-lines; pressure distribution in stationary and accelerated systems; fluid forces; hydrostatics; manometry; buoyancy; Reynolds transport theorem

Constitutive Equations and Related Concepts: Continuity equation; momentum equation and angular momentum equation for control volumes; energy equation and Bernoulli equation; Euler's equation for inviscid flow and Navier-Stokes equation for viscous flow; boundary conditions for the basic equations of fluid mechanics; boundary layer; stream function; vorticity and rotation; viscous stresses and strain rates

Turbulent Flows: Introduction to turbulent flows; qualitative issues on turbulence; laminar and turbulent pipe flow; Reynolds number

Potential Theory: Two-dimensional potential theory, velocity potential

Recommended Books:

1. Y. A. Çengel and J. M. Cimbala, Fluid Mechanics: Fundamentals and Applications, Publisher: McGraw-Hill, 2nd ed., (2010).
2. P. K. Kundu, I. M. Cohen and D. R. Dowling, Fluid Mechanics, Publisher: Elsevier : Academic Press, 5th ed. (2012).
3. Y. Nakayama and R. F. Boucher, Introduction to Fluid Mechanics, Publisher: Butterworth-Heinemann, (2000).
4. G. Falkovich, Fluid Mechanics, Publisher: Cambridge University Press, (2011).

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PHY-624 INTRODUCTION TO PLASMA PHYSICS

Credit Hours: Three (3)

Pre-requisite: Electromagnetic Theory-II

Objective(s): To introduce the basic concepts of the physics of plasmas and its major applications

Course Contents:

Introduction: Plasmas in Nature; Basic Properties of Equilibrium Plasmas; Quasi-neutrality; Debye Shielding; Transmission of Electromagnetic waves through Plasmas; Degree of Ionization and Saha Equation; Applications of Plasmas.

Single Particle Motions: Single Particle Motion in Uniform, Non-uniform and time-varying Electric and Magnetic fields; Guiding Center Drifts; Adiabatic Invariants.

Plasma as a Fluid: Plasma Physics and Electromagnetics; The Fluid Equations of Motion; Fluid Drifts Parallel and Perpendicular to Magnetic Field; The Plasma Approximation.

Waves in Plasmas: Dispersion Relations; Plasma Oscillations; Electron Plasma Waves; Sound Waves; Ion Waves; Validity of the Plasma Approximation; Comparison of Electron and Ion Waves; Electron Oscillations and Ion Waves Perpendicular to Magnetic Field; The Lower Hybrid Frequency; Electromagnetic Waves with $B_0=0$ and Applications; Electromagnetic Waves Parallel and Perpendicular to Magnetic Field; Cutoff and Resonances; Hydro-magnetic Waves; Magneto-sonic Waves.

Plasma Sources: An Overview of Laboratory Plasmas and their Applications

Introduction to Controlled Fusion: Basic Nuclear Fusion Reactions; Reaction rates and Power Density; Radiation losses from Plasma; Operational Conditions; Lawson Criteria; Magnetic Confinement Fusion; Inertial Confinement Fusion.

Recommended Books:

1. F. F. Chen, "Introduction to Plasma Physics", 2nd ed., Plenum (1984).
2. N. A. Krall and A. W. trivelpiece, ‘Principle of Plasma Physics’, McGraw Hill (1973).
3. S. Glasstone and R. H. Lovberg, "Controlled Thermonuclear Reactions", D. Van Nestrand (1960).
4. D. A. Gurnett and A. Bhattacharjee, “Introduction to Plasma Physics: with space and laboratory application”, Cambridge University Press, 2005.
5. T. J. M. Boyd and J. J. Sanderson, “The Physics of Plasmas”, Cambridge University Press, 2003.

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PHY-625 **METHODS OF EXPERIMENTAL PHYSICS**

Credit Hours: **Three (3)**

Pre-requisites: Labs. I to VI

Objective(s): The objective of this course is to learn about the vacuum techniques and sensor technologies, the use of computer to acquire data from instruments and analysis of collected data.

Course Contents:

Vacuum Techniques: Gas Transport; Throughput; Pumping Speed; Rotary pumps; Diffusion pumps; Sorption pumps; Production of ultrahigh vacuum; Fundamental concepts; Guttering pumps; Ion pumps; Cryogenic pumps; Turbo molecular pumps; Measurement of total pressure in Vacuums Systems; Units; Pressure ranges; Manometers; Pirani gauges; The McLeod gauges; Mass spectrometer for partial measurement of pressure; Design of high Vacuum system; Surface to Volume ratio; Pump Choice; Pumping system design; Vacuum Components; Vacuum valves; Vacuum Flanges; Liquid Nitrogen trap; Mechanical & Electrical feed through; Leak detection; Basic consideration; Leak detection equipment; Special Techniques and problems; Repair Techniques;

Sensor Technology: Sensors for Temperature; Heat; Pressure; Displacement; Rotation; Flow; Level; Speed; Position; Phase; Current; Voltage; Power; Magnetic field; Tilt; Metal; Explosive materials.

Introduction to Computer Interfacing: GPIB Interface; RS 232; DA/AD conversion; Visual c/visual Basic.

Data Analysis: Evaluation of measurement; Systematic Errors; Accuracy; Accidental Errors; Precision; Statistical Methods; Mean Value and Variance; Statistical Control of Measurements; Errors of Direct measurements; Rejection of data; Significance of results; Propagation of errors; Preliminary Estimation; Errors of Computation; Least squares fit to a polynomial; Nonlinear functions; Data manipulation; Smoothing; Interpolation and extrapolation; Linear and parabolic interpolation.

Recommended Books:

1. F. James, “Statistical Methods in Experimental Physics”, World Scientific Company, 2nd ed. (2006).
2. M. H. Hablanian, “High-Vacuum Technology”, Marcel Dekker, 2nd ed. (1997).
3. P. Bevington and D. K. Robinson, “Data Reduction and Error Analysis for Physical Science”, McGraw Hill, 3rd ed. (2002).
4. S. Tavernier, “Experimental Techniques in Nuclear and Particle Physics”, Springer, (2010).
5. J. B. Topping, “Errors of Observations and Their Treatment”, Springer, 4th ed. (1972).

PHY-626 INTRODUCTION TO QUANTUM COMPUTING

Credits: Three (3)

Prerequisites: Quantum Mechanics I

Objectives: The main objective of this course is to provide an introduction to theory and practice of quantum computation. This course explores how properties of quantum mechanical systems can be exploited to design quantum algorithms which are efficient than classical ones.

Course Contents:

Basic concepts: Hilbert spaces; tensor products; notion of Qubits.

Introduction to computer science: Turing machine; universal Turing machine; circuits; Quantifying computational resources; computational complexity; P and NP problems.

Quantum circuits: Quantum algorithms; single qubit operations; controlled operations; universal quantum gates; simulation of quantum systems.

Quantum algorithms: Quantum Fourier transform and its application to period finding; order finding and factoring; Grover's search algorithm and its applications

Quantum error correction codes: The three qubit phase flip code; the three qubit bit flip code; The Shor code

Physical realization of quantum computers: Harmonic oscillator quantum computer; Ion trap.

Recommended Books:

1. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press (2000).
2. Steane, "Quantum Computing", Rep. Prog. Phys. 61 117–173 (1998).
3. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Foundation Books (2007).
4. C. P. Williams and S. H. Clearwater, "Exploration in Quantum Computation" Springer, 2nd ed. (2011).
5. P. Bouwmester, A. Ekert, and A. Zeilinger, "The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation", Springer (2010).
6. R. K. Brylinsky and G. Chen, "Mathematics of Quantum Computation" by Chapman & Hall/CRC (2002).

PHY-627 QUANTUM INFORMATION

Credits: Three (3)

Prerequisites: Quantum Mechanics I

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Objectives: The main objective of this course is to provide broad overview of quantum information to students thus enabling them to keep up with recent developments in this rapidly growing field. The main emphasis is to understand basic quantum phenomena contributing to quantum information and then their application to important quantum information processes.

Course Contents:

Mathematical Formalism: Hilbert spaces; Density matrix formalism; Tensor product for many body systems; Pauli matrices

Qubits: Introduction to qubits; familiarizing with single qubit algebra; concept of Bloch vector and pure and mixed state; Introduction to entangled states and Bell states

Bell Inequalities: EPR paradox leading to Bell inequality to be satisfied by local hidden variable theory; Violation of Bell inequality by entangled states; CHSH inequality and maximum violation.

Measurement theory: Projective measurements; POVM and Neumark theorem; Application of POVM to unambiguous state discrimination and minimum error state estimation

Entanglement as a physical resource: No cloning theorem; trivial cloning and optimal cloning; Application of entanglement to quantum teleportation; quantum dense coding; quantum cryptography and quantum state discrimination

Entropy and Information: Shannon entropy; basic properties of entropy; Von Neumann entropy

Recommended Books:

1. M. A. Nielson and I. L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press (2000).
2. V. Vedral, "Introduction to Quantum Information Science", Oxford University Press, 2007.
3. Cambridge University Press, 10th *ed*. (2010).
4. W. Steeb and Y. Hardy, "Problems and Solutions in Quantum Computing and Quantum Information", World Scientific Publishing, 3rd *ed*. (2011).
5. Book on general quantum mechanics: A. Peres, Quantum Theory: Concepts and Methods, Kluwer Academic Publishers (2002).
6. Seth Lloyd's notes on quantum information available online at: *web.mit.edu/2.111/www/notes09/spring.pdf*
7. J. Preskill, "Lecture notes on Quantum Information and Computation", http://www.theory.caltech.edu/~preskill/ph219/index.html#lecture

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PHY-628 QUANTUM OPTICS

Credit Hours: Three (3)

Pre-requisites: Electromagnetic Theory-I

Objectives: The main objective of this course is to understand the quantization of electromagnetic radiations and its interaction with matter. Establishment of the quantum theory of electromagnetic radiation that includes the number state and coherent state representations, which is used to analyze the light-matter interactions. The light-matter interaction is essential to study ultra-cold matter, quantum sensing and quantum control.

Course Contents:

Basic Concepts: Introduction to electromagnetic (e.m.) radiation; energy contained by e.m. field; historical development of ideas of optics and photons

Quantization of Electromagnetic field: Quantization of single mode; multimode and thermal fields; number states; field fluctuations; vacuum fluctuations and zero-point energy; coherent states; minimum uncertainty states

Atom-Field Interaction: Absorption and emission of radiation by atoms; semi-classical and quantum mechanical treatment of atom-field interaction; beam splitters and interferometers

Non-classical Properties of light: Non-classical light with quadrature squeezing; amplitude squeezing; Photon anti-bunching; Schrodinger cat state; optical test of quantum mechanics viz. parametric down conversion of photons; Hong-Ou-Mandel interferometer; quantum erasers; superluminal tunneling of photons and local realistic theories

Applications and Advanced topics: Bell's theorem; experiments in cavity QED and with trapped ions; optical control of atoms: quantum control.

Recommended Books:

1. C. Gerry and P. Knight, "Introductory Quantum Optics", Cambridge University Press (2005).
2. M. Fox, "Quantum Optics: An Introduction", Oxford University Press, (2005)

PHY-629 QUANTUM FIELD THEORY

Credit Hours: Three (3)

Pre-requisites: Quantum Mechanics-II

Objectives: The main objective of this course is to further enhance the understanding of classical and quantum field theories.

Course Contents:

Lagrangian Field Theory: Classical Field Theory. Canonical Quantization. Noether's theorem.

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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. M. Maggiore, "A Modern Introduction to Quantum Field Theory (Oxford Master Series in Statistical, Computational, and Theoretical Physics)", Oxford University Press (2005)

PHY-630 DIGITAL ELECTRONICS

Credit Hours: Three (3)

Pre-requisites: Basic Electronics

Objective(s): To learn the basics of digital electronics such a as Boolean Algebra, to develop logic circuit using the Boolean Algebra and understand the computer interface and micro-controller along with the embedded systems

Course Contents:

Review of Number Systems: Digital Systems; Characteristics of digital systems and analog Vs digital system; Binary Numbers (Decimal, Binary, Octal and Hexadecimal number systems); their inter-conversion; concepts of logic; truth table; basic logic gates.

Boolean Algebra: Basic Definitions; De Morgan's theorem; Simplification of Boolean expression by Boolean Postulates and theorem; Standard Representations for Logical/Boolean Functions (sum of product & product of sum Forms); K-maps(one, two, three and four-variables Maps) and their uses; Don't Care Conditions; Different Codes (BCD, EBCDIC, ASCII, Gray etc.); Parity in Codes.

IC Logic Families: Basic characteristics of a logic family (Fan in/out, Propagation delay time, power dissipation, noise margins, speed power product, current Sinking and current Sourcing); Different logic-based IC families (DTL, RTL, ECL, TTL, and CMOS).

Combinational Logic Circuits: Introduction; Logic circuits based on AND–OR, OR-AND, NAND, NOR Logic; gate design; addition; subtraction (One's and Two's Complements); Half

and Full Adders; Half and Full Subtractors; Encoder; Decoder; PLA; Exclusive OR and NOR gates.

Sequential Logic Circuits: Introduction; Flip-flops; Clocked (RS-FF, D-FF, T-FF, JK-FF); Shift Registers; Counters (Ring, Ripple, up-down, Synchronous); A/D and D/A Converters.

Memory Devices: Memory terminology; Classification of Memories; ROM; PROM; EAPROM; EEPROM; RAM (Static and dynamic); Memory mapping techniques.

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

Recommended Books:

1. M. M. Mano, "Digital Logic and Computer Design", Prentice Hall, (1995).
2. R. Tokheim, "Digital Electronics", McGraw Hill, 7th ed. (2007).
3. B. B. Brey, "The Intel Microprocessors: Architecture, Programming and Interfacing", Merril, 2nd ed. (1991).
4. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. (2009).
5. T. Wilmshurst, "The Design of Small-Scale Embedded Systems", Palgrave, (2001).

PHY-631 INTRODUCTION TO LASER PHYSICS

Credit Hours: Three (3)

Pre-requisite: Quantum Mechanics-I

Objective(s): The main objective of the course is to introduce students to basic principles, characteristics, and some applications of lasers. This course provides the foundation for further studies at graduate level in the field of lasers and applied photonics.

Course Contents:

Introductory Concepts: Spontaneous Emission; Absorption; Stimulated Emission; Unique Properties of Laser Light: Monochromaticity, Coherence, Directionality, and Brightness

Energy Levels of Atoms, Molecules and Semiconductors: Energy Levels for One-electron and Multi-electron atoms; Radiative and Non-radiative Transitions; Selection Rules; Line Broadening Mechanisms and Line-widths; Energy Levels in Molecules; liquids; solids and Semiconductors

Radiation and Thermal Equilibrium: Boltzman's Distribution; Absorption and Stimulated Emission; Principle of Detailed Balance; Einstein's A & B Coefficients

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Population Inversion and Gain: Population Inversion as a Necessary Condition; Gain Coefficient and Stimulated Emission Cross-section; Small Signal Gain; Gain Saturation; Gain Threshold for Lasers with and without Resonators

Laser Resonators: Plane Parallel (Fabry-Perot) Resonator; Longitudinal and Transverse Cavity Modes; Concentric Resonator; Confocal; Resonator; Generalized Spherical Resonator; Ring Resonator; Stable Resonators; Unstable Resonators; Matrix Formulation of Geometrical Optics; Stability Condition; Standing and Traveling Waves in a two Mirror Resonator

Laser Pumping Requirements and Techniques: Three- and Four-Level Laser Systems; Optical pumping; Flash lamp and Laser; Electrical Discharge and Collision Pumping; Indirect Pumping; Chemical Pumping; Electrical Pumping of Semiconductors; Threshold Pump Power; Pumping Efficiency; Pumping Geometries

Continuous Wave (CW) and Pulsed Lasers: Steady State and Transient Population Inversions; Rate Equations; Relaxation Oscillation; Q-Switching and Mode-Locking Methods; Phase Velocity; Group Velocity and Group-Delay Dispersion; Laser Tuning

Lasers Systems: Solid State Lasers: Ruby Laser, Nd: YAG Laser; Semiconductor Lasers: Homojunction Lasers; Heterostructure Lasers; Gas Lasers**:** He-Ne Laser, CO_2 Laser, Ar Laser; Excimer Lasers, Free-Electron Lasers; X-Ray Lasers; Metal Vapor Lasers; Dye Lasers

Laser Applications: Material Processing: Surface Hardening, Cutting, Drilling, Welding Holography, Optical Communication; Medical Applications; Remote Sensing; Defense and Industrial Applications

Recommended Books:

1. W. T. Silfvast, “Laser Fundamentals”, Cambridge University Press, 2nd ed. (2008).
2. O. Svelto, “Principles of Lasers”, Springer, 5th ed. (2009).
3. J. Hecht Understanding lasers: an entry-level guide, New York: IEEE Press (1994).
4. J. T. Verdeyen "Laser electronics" Englewood Cliffs, New Jersey Prentice Hall (1995).
5. K. Thyagarajan, A.K. Ghatak."Lasers, theory and applications" New York Plenum Press (1981).

PHY-632 **LASER APPLICATIONS**

Credit Hours: **Three (3)**

Pre-requisites: Introduction to Laser Physics

Objective(s): This course is designed to introduce the major applications of lasers in different fields of science and technology

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Course Contents:

Fundamentals of Lasers: Review of the working principles of a laser; Laser Resonators and Modes; Q-switching; Mode-locking; Ultrafast pulse generation; Fixed Frequency and Tunable Lasers

Characteristics of Laser Light: Laser wavelength**;** CW and pulsed modes**;** Laser power; energy per pulse; pulse duration; repetition rate; frequency width; beam divergence

A Survey of Laser Sources: Brief descriptions of solid-state lasers; gas lasers; semiconductor lasers; dye lasers; excimer lasers; metal vapor lasers; fiber lasers

Applications of Low-Power Lasers: Scanning; Alignment; Surface Monitoring; Position and Velocity Measurements; Laser Interferometry; Laser Radar**;** Environmental Applications

Applications of High-Power Lasers: Laser Material Processing including Cutting; Drilling; Trimming; Welding; Marking and Surface Treatment; Surface Cleaning and Decontamination; Laser Ultrasonic, Laser Produced Plasmas and Laser Fusion

Laser Applications based on Frequency Resolution: Photo-physical and Photo-chemical Processes; Laser Isotope Separation; Laser Enhanced Chemical Reactions

Laser Applications based on Time Resolution: Laser Radar; Ultrafast Processes

Optical Communications, Data Storage and Processing: Fiber Optics; High Speed Communication; Optical Holography; Optical Computers

Medical Applications: Ophthalmology; Dermatology; Photodynamic Therapy; Dentistry; Microsurgery

Military Applications: Ranging and Tracking; Target Designation; Guidance System; Directed Energy Weapons

Lasers in Scientific Research: Laser Spectroscopy

Laser Safety: Eye and Skin Hazards, Electrical and Chemical Hazards

Recommended Books:

1. K. R. Nambiar, “LASERS: Principles, Types and Applications”, New Age, (2009).
2. K. Thyagarajan, “Lasers: Fundamentals and Applications”, Springer, 2nd ed. (2010).
3. J. F. Ready, "Industrial Applications of Lasers", Academic Press, 2nd ed. (1997).
4. W. M. Steen, J. Mazumder and K. G. Watkins, “Laser Material Processing”, Springer, 4th ed. (2010).
5. W. T. Silfvast, “Laser Fundamentals”, Cambridge, 2nd ed. (2008).

PHY-633 EXPERIMENTAL TECHNIQUES IN PARTICLE AND NUCLEAR PHYSICS

Credit Hours: Three (3)

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Objective(s): To give students an idea of the experimental techniques used to understand nuclear and sub-nuclear phenomena

Course Contents:

Review of Basic Concepts: Units used in particle physics; Types of particles to be detected; Cross section and Decay width; Lab Frame and CM frame; Pseudo rapidity; History of Accelerators; Linear accelerators; Circular accelerators; Introduction to RHIC, Tevatron, LEP, LHC

Introduction to Accelerators: Lattice and geometry; The arcs; Periodicity; Aperture; Beam crossing angle; Luminosity; RF cavities; Power requirements; Longitudinal feedback system; Injection; Injection scheme; PS; SPS; Magnets; Cryogenics; Vacuum system

Introduction to Detectors: Introduction to detectors; Need of detectors; Passage of radiation through matter; Cross-section; Interaction probability in a distance x; Mean free path; Energy loss of heavy charged particles by atomic collisions; Bohr's, calculation – classical case - The Bethe Bloch formula; Cherenkov radiation; Energy loss of electron and photon; Multiple coulomb scattering; Energy straggling; The interaction of photons; The interaction of neutrons

General Characteristics of Detectors and Gas Detectors: Sensitivity; Detector response; Energy resolution – The Fano-factor; The response function; Response time; Detector efficiency; Dead time- Ionization detectors; Gaseous ionization detectors; Ionization & transport phenomenon in gases; Transport of electrons and ions in gases; Avalanche multiplication; The cylindrical proportional counter; The multi-wire proportional counter; The drift chambers; Time projection chambers; Liquid ionization detector

Scintillators, Photomultipliers, Semi-conductor Detectors: Scintillation detectors; Organic scintillation; Inorganic crystals; Gaseous scintillators Glasses; Intrinsic detector efficiency for various radiations; Photomultipliers; Basic construction and operation; The photocathode; The electron-optical input system; Semiconductor detectors; Silicon diode detectors; Introduction to CMS and its detectors

Detector Software and Physics Objects: Introduction to Linux operating system; Introduction to CMS software (CMSSW); Basic infra structure of software; Introduction to PYTHIA; Introduction to GEN, SIM, DIGI, RECO; reconstruction of final state objects.

Recommended:

1. The Large Hadron Collider Conceptual Design CERN/AC/95-05 (LHC)
2. Detector performance and software, Physics Technical Design Report, Volume1
3. Techniques for Nuclear and Particle Physics Experiments by W.R. Leo
4. R. Fernow, "Introduction to experimental particle physics", Cambridge University Press, (1989).
5. D. H. Perkins, "Introduction to High Energy Physics", Cambridge University Press, 4th ed. (2000).

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PHY-634 ELECTRONIC MATERIALS AND DEVICES

Credit Hours: **Three (3)**

Pre-requisite: Electronics-I, Optics

Objective(s): To understand the relation between electrical, optical and magnetic devices

Course Contents:

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

Device Fabrication Processes: Oxidation, diffusion, ion implantation, lithography, thin-film deposition techniques like evaporation, sputtering, chemical vapour deposition (CVD), epitaxy etc.

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

Dielectric Materials: Polarization mechanisms, dielectric constant and dielectric loss, capacitor dielectric materials, piezoelectricity, ferroelectricity and pyroelectricity

Optoelectronic Devices: Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics, solar cell basics, LEDs, Lasers, displays, LCDs

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

Recommended Books:

1. R. F. Pierret, "Semiconductor Device Fundamentals", Addison Wesley, 2nd ed. (1996).
2. N. Braithwaite, and G. Weaver, "Electronic Materials", MA: Butterworth, 2nd ed. (1990).
3. S. O. Kasap, "Electronic Materials and Devices", McGraw Hill, 3rd ed. (2005).
4. R. C. O'Handley, "Modern Magnetic Materials: Principles and Applications", Wiley Inter-Science, (1999).
5. D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall, 2nd ed. (1998).

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PHY-635 INTRODUCTION TO PHOTONICS

Credit Hours: Three (3)

Pre-requisites: Optics

Objective(s): To study the application of light and photonic devices including detectors

Course Contents:

Guided Wave Optics: Planar slab waveguides; Rectangular channel waveguides; Single and multi-mode optical fibers; waveguide modes and field distributions; waveguide dispersion; pulse propagation

Gaussian Beam Propagation: ABCD matrices for transformation of Gaussian beams; applications to simple resonators

Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces; Jones Calculus; retardation plates; polarizers

Electro-optics and Acousto-optics: Linear electro-optic effect; Longitudinal and transverse modulators; phase and amplitude modulation; Mach-Zehnder modulators; Coupled mode theory; Optical coupling between waveguides; Directional couplers; Photoelastic effect; Acousto-optic interaction and Bragg diffraction; Acousto-optic modulators; deflectors and scanners

Optoelectronics: p-n junctions; semiconductor devices; laser amplifiers; injection lasers; photoconductors; photodiodes; photodetector noise

Recommended Books:

1. B. E. A. Saleh and M. C. Teich, "Fundamentals of Photonics", John Wiley, 2nd ed. (2007).
2. J. M. Liu, "Photonic Devices", Cambridge University Press, (2009).
3. Yariv and P. Yeh, "Photonics: Optical Electronics in Modern Communications", Oxford University Press, (2006).

PHY-636 INTRODUCTION TO MATERIAL SCIENCE

Credit Hours: Three (3)

Pre-requisites: Solid State Physics-I

Objective(s): This course will explore important aspects of materials incorporating elements of applied physics and chemistry, relationship between the structure of materials at atomic or molecular scales and their macroscopic properties, defects and thermodynamics. The microstructure-mechanical properties relationship will be also addressed.

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Course Contents:

Introduction: Classification of Materials; Metals; Ceramics; Polymers; Composites; Semiconductors; Biomaterials; Smart and Nano-materials; Properties and Uses of these Materials.

Atomic Structure of Materials: The packing of atoms in 2-D and 3-D; Lattices and crystal systems in 3-D; Symmetry; Unit cells of the SC, BCC, FCC and HCP Crystal structure; Interstitial structures; Density computation; Indexing lattice directions and lattice planes; Interplanar spacing; Bragg's law and the intensities of Bragg reflections.

Imperfections in Solids: Vacancies; Impurities; Dislocations; Interfacial defects; Bulk or volume defects; Atomic vibrations.

Thermodynamics and Phase Diagrams: Microstructure and microscopy; One component phase diagrams; Pressure vs. temperature; Temperature vs. composition; Equilibrium; Thermodynamic functions; Gibbs free energy; Development of microstructure; Binary phase diagrams; Solidification; Diffusion mechanisms; Nucleation and growth of a new phase; Materials fabrication.

Mechanical Behavior of Materials: Normal stress and normal strain; Shear stress and shear strain; Elastic and plastic deformation; Young's modulus; Shear modulus; Poisson's ratio; Elastic strain energy; Yield stress, Dislocations and plastic deformation; Slip systems; Dislocations and strengthening mechanisms; Fracture mechanics; Ductile and brittle fracture; Griffith criterion; Ductile-brittle transition temperature; Cyclic stresses and fatigue; Creep.

Polymers: Polymer basics; Polymer molecules; Molecular weight and shape; Step growth polymerization; 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;

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).
4. http://www.msm.cam.ac.uk/teaching/index.php,
5. http://www.doitpoms.ac.uk/

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PHY-637 INTRODUCTION TO NANO SCIENCE AND NANOTECHNOLOGIES

Credit Hours: Three (3)

Pre-requisite: Solid State Physics, Quantum Mechanics

Objective(s): In this course, one will learn the importance of this interdisciplinary field, how such materials are developed atom by atom by incorporating the concepts and applications of nano-materials into nanotechnologies and how nanotechnology would be helpful to change our society in future.

Course Contents:

Introduction: Feynman talks on small structures; Nano-scale; Nanotechnology in nature.

Nano Materials: Nanoparticles; Quantum dots; Nano-wires; Nano-tubes; Magnetic nano-structures; Nano thermal devices; Nano fluidic devices; Biomimetic materials;

Quantum Effects: Wave particle duality; Energy quanta; Uncertainty principle; De Broglie relation; Moore's law; Tunneling;

Fabricating Nano-structures: Solid state Reaction technique; Vapor deposition Method; Sol gel; Lithography (photo and electron beam); MBE; Self-assembly; Nano junctions; Thin Films; Sputtering; Self-assembled films

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; Single electron transistor; Resonant tunneling;

Nano Biotechnology: DNA micro-arrays; Protein and DNA Assembly; Digital cells; Genetic circuits; DNA computing;

Characterization Techniques: XRD; Electron Microscopy (STM, AFM, SEM and TEM); Fluorescence methods; Synchrotron Radiation;

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

Recommended Books:

1. B. Bhushan, "Springer Hand Book of Nanotechnology", 3rd Edition, Springer Berlin Heidelberg, (2010).
2. C. Binns, "Introduction to Nanoscience and Nanotechnology (Wiley Survival Guides in Engineering and Science)", Wiley, (2010).
3. S. Lindsay, "Introduction to Nanoscience", Oxford University Press, (2009).
4. S.C. Tjong, Nano-crystalline Materials: Their synthesis-Structure-property Relationship and Applications, Elsevier, 2006.

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5. Y.Gogotsi (Editor), Nano-Materials Hand Book, CRC Press, Taylor & Francis Group, (2006).
6. M.J. Schulz, A.D. Kelkar and M.J. Sundaresan (Editors), Nano-engineering of structural, Functional and Smart Materials, CRC Press, Taylor & Francis Group, (2006).

PHY-638 PARTICLE PHYSICS

Credit Hours: Three (3)

Pre-requisites: Quantum Mechanics-I

Objective(s): In this course, one will learn about the concepts of Quantum Electrodynamics, Quantum Chromo-dynamics and related special topics to build up a strong base in theoretical physics.

Course Contents:

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

Relativistic Kinematics: Lorentz transformations. Four-Vectors. Energy and momentum. Particle collisions. 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. J. 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).

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PHY-639 COMPUTER SIMULATIONS IN PHYSICS

Credit Hours: **Three (3)**

Pre-requisites: Calculus-II, Linear Algebra, Probability and Statistics, Differential Equations, ntroduction to Computing and Mechanics

Objective(s): The aim is to develop one's ability to turn theoretical ideas of mathematics and physics into models speculated outcomes via computer simulations.

Course Contents:

Programming for Scientific Computation: unix/linux basics, the editing-coding-compiling-debugging-optimizing-visualizing-documenting production chain, FORTRAN 95

Numerical Programming: Functions: approximation and fitting, Numerical calculus. Ordinary differential equations, Matrices, Spectral analysis, Partial differential equations

Modeling and Simulation: Molecular dynamics simulations, Modeling continuous media Monte Carlo simulations

Project: A project will be chosen by the student in consultation with the instructor. Selection of the project should be done soon after the module on modelling and simulation starts and and continue over the course of the rest of the semester. The final part of the course is reserved for presentation of preliminary and final results.

Recommended Books:

1. T. Pang, “An Introduction to Computational Physics”, Cambridge University Press, (2008).
2. R. Landau, M. Paez, C. Bordeianu, “A Survey of Computational Physics”, Princeton University Press, (2008).

PHY-640 SURFACE PHYSICS

Credit Hours: **Three (3)**

Pre-requisite: Solid State Physics-I

Objective(s): To understand the basics of surface physics, strengthen the previous knowledge of Solid-State Physics and Quantum Mechanics

Course Contents:

An Introduction to Surfaces: What is a surface? The energetics and thermodynamics of creating a surface. An introduction to surface Physics. Surface energies and the Wulff Theorem.

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Studying Surfaces: What is UHV? Do we need UHV to study surfaces? The kinetic theory of gases, concept of vacuum and standard vacuum hardware components. Comparison of different types of pumps with measurement of vacuum pressure. Preparing a clean surface.

Surface Structures and Reconstructions: Lattice concept. 3-D crystal structures, 2D surface structures. Specific types of surface, fcc, hcp, bcc and stepped surfaces and a discussion of their relative energies. More complex ceconstruction, stability, growth mechanisms, adsorption. Desorption and experimental probes of surface structure such a LEED and RHEED. The structure of semi-conductor surfaces. The surface structures of very small metal particles.

Adsorption, Desorption Bonding, Catalysis and Growth Processes: Adsorption mechanisms and kinetics chemisorption vs. physisorption, the kinetics of adsorption, potential energy curves and adsorption energetics. Adsorption mechanisms and kinetics for low coverages Langmuir Isotherms, derivation, adsorbate phase diagrams and phase transitions.

The Structure of Adsorbate Layers: Experimental probes of surface structure such as LEED and RHEED. Growth processes, vibrational spectroscopy, catalysis, Desorption.

The Electronics and Magnetic Structure of Surfaces: Band theory, Free electron theories and the work function. The electronic structure of semiconductor surfaces, Electron emission processes. Magnetic processes at surfaces.

Electron-Surface Interactions: Electron diffraction and quasi–elastic scattering, comparison of particle scattering techniques. Electron spectroscopes, Discussion of the merits of different types of electron energy analyzers and electron detectors. Signal processing and spectral analysis. Theory and practice of Auger electron spectroscopy, Quantification of Auger spectra, Auger depth. Profiling.

Atom/ion surface interactions: Comparison of particle scattering techniques, An Introduction to the theory and practice of SIMS, SIMS imaging and depth profiling, Auger depth profiling, theory and practice of Rutherford. Back scattering.

Surface Microscopy: Classification of microscopy techniques, Basic concepts in surface imaging and localized spectroscopy, Imaging XPS, Optical microscopy, STEM. SEM. SPM. An introduction to the theory and practice of scanning Tunneling Microscopy, Scanning probe microscopy techniques, Atomic Force Microscopy.

Recommended Books:

1. John A. Venables, “Introduction to Surface and Thin Film Processes”, Cambridge University Press (2000).
2. Zangwill, “Physics at Surfaces”, Cambridge University Press, (1988).
3. D. P. Woodruff and T. A. Delchar, “Modern Techniques of Surface Science”, Cambridge University Press, 2nd ed. (1994).
4. D. Briggs and M. P. Seah, “Practical Surface Analysis”, Vol-I, John Wiley, 2nd ed. (1990).

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5. J. B. Hudson, "Surface Science, an Introduction", Wiley-Interscience, (1998).
6. H. Luth, "Surfaces and Interfaces of Solids", Springer-Verlag, 2nd ed. (1993).
7. M. Prutton, "Introduction to Surface Physics", Oxford University Press, (1994).
8. R. I. Masel, "Principles of Adsorption and Reaction on Solid Surfaces", Wiley-Interscience, (1996).

PHY-641 RENEWABLE SOURCES OF ENERGY

Credit Hours: Three (3)

Objectives: To give students an understanding of the renewable energy resources

Course Contents:

Energy Scenarios: Importance of energy, world primary energy sources, energy demand, supplies, reserves, growth in demand, life estimates, and consumption pattern of conventional energy sources: oil, gas, coal, hydro, nuclear etc.

Energy & Environment: Emission of pollutants from fossil fuels and their damaging effects, and economics impact; Renewable energy and its sustainability. Renewable Scenarios: Defining renewable, promising renewable energy sources, their potential, availability, present status, existing technologies and availability.

Solar Energy: Sun-Earth relationship, geometry, sun path and solar irradiance, solar spectrum, solar constant, atmospheric effects, global distribution, daily and seasonal variations, effects of till angle, resource estimation, extraterrestrial, global, direct, diffused radiation, sun shine hours, air mass, hourly, monthly and annual mean, radiation on tilt surface, measuring instruments.

Solar Thermal: Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency; low temperature applications: water heating, cooking, drying, desalination, their designs and performance; concentrators, their designs, power generation, performance and problems.

Photovoltaics: 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, packing fraction, modules, arrays, controllers, inverters, storage, PV system sizing, designing, performance and applications.

Wind: 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.

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Hydropower: Global resources, and their assessment, classification, micro, mini, small and large resources, principles of energy conversion; turbines, types, 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 non-traditional uses: utilization process, gasification, digester, types, energy forming, Environment issues. Resources availability; digester, their types, sizes, and working, gas production, efficiency; environmental effects;

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

Waves and Tides: Wave motion, energy, potentials, sites, power extraction, and transmission, generation of tides, their power, global sites, power generation, resource assessment, problems, current status and future prospects.

Hydrogen Fuel: Importance of H_2 as energy carrier, Properties of H_2, production, hydrolysis, fuel cells, types, applications, current status and future prospects.

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

Energy Storage: Importance of energy storage, storage systems, mechanical, chemical, biological, electrical, fuel cells etc.

Recommended Books:

1. J. W. Twidell and A. D. Weir; Renewable Energy Resources; E & F.N. Spon. Ltd. London. (1986).
2. M. Iqbal; An Introduction to Solar Radiation: Academic Press, Canada. (1983).
3. S. Roberts, A Practical Guide to Solar Electricity, Prentice Hall Inc. USA, (1991).
4. M. A. Green; Solar Cells, Operating Principles, Technology, and system Application: Prentice Hall, Inc. USA, (1982).
5. T. J. Jansen, Solar Engineering Technology; Prentice Hall Inc. USA, (1985).
6. V. D. Hunt, Wind Power, A Book on Wind Energy Conversion System; Litton Educational Publishing Inc. (1981).
7. E. C. Price, P. N. Cheremisinoff; Biogas, Production and Utilization; Ann Arbor Science, USA, (1981).
8. Campbell, Biomass, Catalysts and liquid fuels; Technonic Publishing Co. Inc. USA, (1983).

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PHY-642 MATERIALS CHARACTERIZATION TECHNIQUES

Credit Hours: Three (3)

Objectives: This course provides a detailed account of some common experimental techniques in physics research. It introduces the basic working principles, the operational knowhow, and the strength and limitations of the techniques.

Course Contents:

Optical Microscopy: Reflected light microscopy, using transmission mode, polarized light microscopy, using optical microscope, resolution and imaging, sample preparation for metals, ceramics and polymers.

Electron Microscopy: SEM gun construction, magnetic lenses, electron detectors, SEM imaging parameters, high resolution microscopy, electron gun parameters, imaging parameters, basic sample preparation, energy dispersive spectroscopy

Electro-optics of the TEM (lenses, lens aberrations), Image formation and imaging modes in TEM, Diffraction theory and Diffraction patterns, Dark and bright field imaging, Image interpretation, High resolution microscopy and Lattice imaging, TEM Sample preparation

Scanning Probe Microscopy: Introduction to scanning probe microscopy, Tip surface interaction, modes of operation, the scanner, tip and cantilever, feedback, artefacts from scanner, tip and others. Scanning Tunneling microscopy.

X-ray Diffraction Techniques: X- rays, production and measurements of x-rays, Bragg's law, Single crystal diffraction, determining lattice parameters accurately, relationship between crystalline structure and x-ray data, powder diffraction, phase identification, textured samples.

Raman Spectroscopy: Basic theory and principles of Raman spectroscopy, absorption and scattering, Ryleigh scattering, stokes and anti-stokes, lattice modes, number and symmetry of vibrations, some basic examples of interpreting Raman data.

Fourier Transform Infrared Spectroscopy: Basic theory and concepts of FTIR and its applications.

Recommended Books:

1. R Haynes, Optical microscopy of materials, Kluwer Academic Publishers, 1984
2. Ludwig Reimer, Scanning Electron Microscopy, Physics of Image Formation and Microanalysis, Springer-Verlag Berlin Heidelberg, 1998
3. Meyer, Hug and Bennewitz, Scanning Probe Microscopy: The Lab on a Tip, Springer, 2003
4. Williams and Carter, Transmission Electron Microscopy Kluwer/Plenum Press, 1996 to 2004
5. B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, 3rd edition, Prentice Hall, 2001
6. Ewen Smith, Geoffrey Dent, Modern Raman Spectroscopy – A Practical Approach, John Wiley & Sons Ltd, 2005.

PHY-643 INTRODUCTION TO SCINTILLATION MATERIALS

Credit Hours: Three (3)

Objectives: This course introduces the fundamental principles, mechanisms, and types of scintillation materials used in radiation detection. It aims to develop a deep understanding of scintillation processes, interaction of radiation with matter, and performance parameters relevant to applications in physics, medical imaging, and nuclear instrumentation.

Course Contents:

Introduction and Historical Background Definition of scintillators and scintillation; historical development; significance in detection technology.

Types and Applications of Scintillators Classification of scintillators: organic and inorganic types, single crystal and powder forms; key applications in medical imaging, high-energy physics, homeland security, and space science.

Growth of Single Crystal Scintillators Methods of crystal growth; requirements for purity, transparency, and defect control in scintillator production.

Scintillation Mechanisms Creation of electron-hole pairs, excitation and emission processes, recombination pathways, luminescence centers.

Intrinsic Luminescence in Inorganic Scintillators Excitonic luminescence, core-to-valence transitions, host-lattice effects, quenching phenomena.

Scintillation Materials Overview of major scintillator families: halides (e.g., NaI:Tl), oxides (e.g., BGO, LSO), and mixed oxide systems; criteria for material selection.

Interaction with Ionizing Radiation Mechanisms of interaction for high-energy photons, charged particles, and neutrons; energy transfer and light yield response.

Performance Parameters of Scintillators Light yield derivation and factors affecting it, scintillation pulse duration, rise and decay times, afterglow and its suppression.

Defects and Scintillator Performance Mechanisms of defect formation, role of impurities and vacancies, impact on energy resolution and stability.

Recommended Books

1. Piotr A. Rodnyi, Physical Processes in Inorganic Scintillators, CRC Press, Boca Raton, New York, 1997.
2. Inorganic Scintillators for Detector Systems, Springer-Verlag, Berlin Heidelberg, 2006.
3. M. Globus, B. Grinyov, J. K. Kim, Inorganic Scintillators for Modern and Traditional Applications, Institute for Single Crystals, Kharkiv, Ukraine, 2005.

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PHY-644 RADIATION PHYSICS

Credit Hours: Three (3)

Objectives: This course aims to develop a comprehensive understanding of the fundamental properties and types of ionizing radiation. It also focuses on the interactions of various radiations with matter and explores their significance in physical systems and medical applications.

Course Contents:

Review of Atomic and Nuclear Physics Structure of atoms and nuclei, atomic energy levels, nuclear stability, types of radioactive decay.

Types and Characteristics of Radiation Alpha, beta, gamma, X-rays, neutrons; properties and distinguishing features; natural and artificial sources of radiation.

Penetrating Power and Particle Range Penetration depth in different media, Bragg peak, range-energy relationships, factors influencing range, significance in applications like proton therapy.

Radioactivity and Decay Laws Activity, decay constants, exponential decay, half-life, mean life, serial decay chains, transition probabilities.

Gamma-Ray Interactions Photoelectric effect, Compton scattering, pair production, attenuation of gamma rays, interaction cross sections, photonuclear reactions.

Characteristic X-rays and Bremsstrahlung Processes of electron capture and internal conversion; emission of characteristic X-rays and bremsstrahlung radiation; Auger electrons.

Neutron Interactions with Matter Elastic and inelastic scattering, radiative capture, cascade reactions, charged-particle emission resulting from neutron interactions.

Charged Particle Interactions Elastic and inelastic collisions, excitation and ionization processes, stopping power, bremsstrahlung emission, semi-classical derivation of Bethe's formula.

Radiation Effects on Matter Ionization damage, excitation effects, chemical and biological consequences, radiation-induced material changes.

Recommended Books

1. Glen F. Knoll, Radiation Detection and Measurements, *4*th Ed., John Wiley & Sons.
2. Nicholas Tsoulfanidis, Sheldon Landsberger, Measurement and Detection of Radiation, 4th Ed., CRC Press, Taylor & Francis Group, 2015.
3. F. Khan, The Physics of Radiation Therapy, 3rd Ed., Lippincott, Williams and Wilkins, Baltimore, MD, 2003.
4. James E. Turner, Atoms, Radiation, and Radiation Protection, 3rd Ed., Wiley-VCH Verlag GmbH & Co. KGaA, 2000.

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LIST OF SUGGESTED EXPERIMENTS

MECHANICS & PROPERTIES OF MATTER

1. Modulus of Rigidity by Static & Dynamic methods (Maxwell's needle, Barton's Apparatus).
2. Measurement of viscosity of liquid by Stoke's / Poisseulli's method.
3. Surface tension of water by capillary tube method.
4. To determine the value of "g" by compound pendulum / Kater's Pendulum.
5. To study the dependence of Centripetal force on mass, radius, and angular velocity of a body in circular motion.
6. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc.
7. To study the conservation of energy (Hook's law)
8. To determine the Young's Modulus by bending beam method.

HEAT, WAVES & OSCILLATIONS

1. To determine thermal emf and plot temperature diagram.
2. Determination of temperature coefficient of resistance of a given wire.
3. Determination of "J" by Callender – Barnis method.
4. To determine the Thermal conductivity of good and bad conductors using Lee's and Searl's apparatus.
5. The determination of Stefan's constant.
6. Calibration of thermocouple by potentiometer.
7. To determine frequency of AC supply by CRO.
8. To study the damping features of an oscillating system using simple pendulum of variable mass.
9. To determine Horizontal/Vertical distance by Sextant.
10. The determination of wavelength of Sodium –D lines by Newton's Ring.
11. The determination of wavelength of light/laser by Diffraction grating.
12. Determination of wavelength of sodium light by Fresnel's biprism.
13. The determination of resolving power of a diffraction grating.
14. The measurement of specific rotation of sugar by Polarimeter and determination of sugar concentration in a given solution.
15. Investigation of phase change with position in traveling wave and measurement of the velocity of sound by C.R.O.
16. To study the combinations of harmonic motion (Lissajous figures).
17. To study the parameters of waves (Beats phenomenon).
18. To study the laws of vibration of stretched string using sonometer.

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ELECTRICITY & MAGNETISM

1. Measurement of resistance using a Neon flash bulb and condenser
2. Conversion of a galvanometer into Voltmeter & an Ammeter
3. To study the characteristics of Photo emission and determination of Plank's constant using a Photo cell.
4. Calibration of an Ammeter and a Voltmeter by potentiometer
5. Charge sensitivity of a ballistic galvanometer
6. Comparison of capacities by ballistic galvanometer.
7. To study the B.H. curve & measure the magnetic parameters.
8. Measurement of low resistance coil by a Carey Foster Bridge.
9. Resonance frequency of an acceptor circuit
10. Resonance frequency of a Rejecter Circuit.
11. Study of the parameter of wave i.e. amplitude, phase and time period of a complex signal by CRO.
12. Measurement of self/mutual inductance.
13. Study of electric circuits by black box.
14. To study the network theorems (Superposition, Thevinin, Norton).

MODERN PHYSICS

1. To study the application of Lorentz force by CRO.
2. To determine the stopping potential by photo cell.
3. To study the spectral characteristics of Photovoltaic cell.
4. To develop understanding and uses of electronic devises including GATS, Transistors.
5. To understand the behaviour of nuclear radiation including beta and gamma radiation.
6. Determination of e/m of an electron.
7. Determination of ionization potential of mercury.
8. To study the characteristic curves of a G. M. counter and use it to determine the absorption co-efficient of β-particle in Aluminum.
9. Determination of range of α particles.
10. Mass absorption coefficient of lead for γ-rays using G.M counter.
11. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils.
12. Measurement of the half life of a radio nuclide. To study the pulse height as a function of the H.H.T. in a scintillation counter.

Head
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13. Measurement of the spectrum of gamma rays from a radioisotope. Shielding and attenuation of gamma rays.
14. To study the characteristics of a solid-state detector and use it to measure the spectra of alpha and beta particles.
15. Determination of Planck's constant (h) by using the photoelectric effect.
16. Determination of the charge on an electron (e) by Millikan's method.
17. The Frank-hertz experiment (Measurement of excitation potential of Hg)

ELECTRONICS

1. Characteristics of a semiconductor diode (Compare Si with Ge diode)
2. Setting up of half & full wave rectifier & study of following factors.
3. Smoothing effect of a capacitor.
4. Ripple factor & its variation with load.
5. Study of regulation of output voltage with load.
6. To set up a single stage amplifier & measure its voltage gain and bandwidth.
7. To set up transistor oscillator circuit and measure its frequency by an oscilloscope.
8. To set up and study various logic gates (AND, OR, NAND etc) using diode and to develop their truth table.
9. To set up an electronic switching circuit using transistor LDR and demonstrate its use as a NOT Gate.
10. Characteristics of a transistor.
11. Use of computer in the learning of knowledge of GATE and other experiments.
12. AC circuits and dielectric constants of water and ice.
13. Radio frequency measurement. Skin effect, etc.
14. Experiments with transmission lines.
15. Measurement of characteristic impedance. Velocity. Standing wave ratio, etc.

ADVANCED EXPERIMENTS

1. To study the generation and measurement of low and high vacuum.
2. Study of random processes and fluctuations in random processes (Poission distribution, etc.)
3. Measurement of transistor hybrid parameters.
4. To build and investigate the properties of hard value multivibrators.
5. Transistor pulse-circuitry (three types of flip flop and the Schmidt trigger circuit).
6. Design of high or medium voltage dc power supply and measurement of the voltage regulation. Ripple factor etc.
7. Design of an L.F.R.C. coupled amplifier and a study of its characteristics.

8. Design of high or medium voltage dc power supply and measurement of the voltage regulation. Ripple factor, etc.
9. Design of a medium wave T.R.F. or superheterdyne receiver and measurement of its sensitivity. Power out-put selectivity, etc. the operational amplifier.
10. To design and build a linear integrator to enable digitization of photo-multiplier pulses, or to design and build a height-to-width converter.
11. To design and build a lotic circuit (using AND/OR/NOR gates) for performing a given function.
12. Study of leaser parameters. Gain characteristics and spectral response of a photo-multiplier tube.
13. Measurement of the total neutron cross-section.
14. To prove the Rutherford law of scattering of charged particles.
15. Measurement of the spectrum of gamma rays from a radioisotope (e.g.Cs) and study of their photoelectric and Compton absorption.
16. Source strength of Co60 by gamma coincidence methods.
17. Determination of the constituents of substance by activation analysis.
18. To examine the characteristics of a Solid-State detector and to use it for alpha and beta Spectroscopy and compare the results with those obtained by a scintillation counter.
19. Use of an analogue computer for solving differential equations.
20. To examine the stopping-power of various substances for thermal neutrons.
21. Determination of the Rydberg constant from the spectrum of hydrogen.
22. Fabry-Perot interferometer used as a gas refractometer.
23. To study the Zeeman Effect for a line in the spectrum of helium.
24. Experiments with microwaves. Study of their optical properties.
25. Electron spin resonance (E.S.R.) by microwave absorption. Nuclear magnetic resonance (N.M.R.) of protons in water.
26. The study of the Mossbauer Effect.
27. The measurement of the Hall Effect in germanium and silicon.
28. To build a medium or short-wave transmitter.
29. Measurement of the conductivity of Si and Ge as a function of temperature.
30. To determine the energy gap in silicon and Germanium.
31. Drift mobility. (Shockley-Haynes experiments for Germanium, demonstrating transistor action).
32. Simple diode manufacture and point-contact transistor.

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TABLE-9 EXTERNAL COURSES OF PHYSICS

S. No.	Course Code	Course Title	Credit Hours
4.	PHY-301	Biophysics	3 (3-0)
1.	PHY-302	Physics-I	3 (3-0)
2.	PHY-203	Physics-II	3 (3-0)

PHY- 301 Biophysics

Credit Hours: Three (3)

Objectives: Describe the physical principles governing biological systems.

Understand biophysical techniques to study the structure and function of biomolecules.

Analyze the dynamics of molecular interactions in biological processes.

Course Contents:

Introduction to Biophysics: Role of physics in biological sciences. Scales in biophysics: molecular, cellular, and organismal levels. Dimensional analysis and order-of-magnitude estimates in biological systems.

Thermodynamics of Living Systems: First and second laws of thermodynamics applied to cells. Gibbs free energy, entropy, enthalpy in biochemical reactions. Statistical interpretation of entropy. Energetics of protein folding and macromolecular assemblies

Diffusion and Random Processes: Random walks and Brownian motion: Langevin equation, Einstein relation. Fick's laws of diffusion and applications to membranes and ion channels. Osmotic pressure and van't Hoff's law. Transport coefficients and frictional forces in viscous media.

Mechanics of Biomolecules and Cells: Elasticity, bending, and stretching of biopolymers (DNA, actin, microtubules). Force–extension relations (Hooke's law, worm-like chain model). Sedimentation, centrifugation, and viscosity in fluids. Reynolds number and low-Reynolds-number hydrodynamics ("life at low Reynolds number").

Molecular Interactions and Binding: Potential energy surfaces in molecular recognition. Binding and dissociation constants, cooperative binding. Kinetics of enzyme–substrate interactions (Michaelis–Menten model). Statistical mechanics of ligand binding

Molecular Motors and Energy Conversion: Myosin, kinesin, dynein as nanomachines. Energy transduction: ATP hydrolysis and efficiency. Ratchet models and stochastic dynamics. Force–velocity relationships in motor proteins.

Membranes, Ion Transport, and Bioelectricity: Physical properties of lipid bilayers (elasticity, capacitance, permeability). Ion transport and Nernst potential. Hodgkin–Huxley model of the action potential. Patch-clamp technique and single-channel conductance.

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Advanced/Contemporary Topics: Computational biophysics and molecular dynamics. Optical tweezers and atomic force microscopy. Biophotonics: fluorescence microscopy, MRI, PET. Nanotechnology and biosensors.

Recommended Books:

1. Nelson, P. (2023). Biological Physics: Energy, Information, Life. Updated Edition; W.H. Freeman.
2. Howard, J. (2001). Mechanics of Motor Proteins and the Cytoskeleton. Sinauer Associates.
3. Davidovits, P. (2018). Physics in Biology and Medicine. 5th Edition; Academic Press.
4. Boal, D. (2012). Mechanics of the Cell. 2nd Edition; Cambridge University Press.
5. Jones, K., Michel, D., & Turner, M. (2019). Introduction to Biological Physics for the Health and Life Sciences. 2nd Edition; Wiley.
6. Weiss, T. (2012). Cellular Biophysics and Modeling. CRC Press.

PHY- 302 Physics-I

Credit Hours: Three (3)

Objectives: Introduce the fundamental principles of mechanics, heat, and wave motion.
Develop problem-solving skills through physical reasoning and quantitative analysis.
Provide a strong foundation in physics for students of other disciplines.

Course Contents:

Kinematics and Dynamics: Motion in one and two dimensions. Displacement, velocity, and acceleration. Newton's laws of motion and their applications. Frictional forces, circular motion, and motion on inclined planes. Work, energy, and power. Conservation of energy and momentum.

Oscillations and Waves: Simple harmonic motion. Energy in oscillatory motion. Damped and forced oscillations. Resonance phenomena.

Wave motion: traveling and standing waves. Superposition principle, interference, and beats. Sound waves and Doppler effect.

Gravitation and Rotational Motion: Newton's law of gravitation. Kepler's laws. Satellite motion and escape velocity. Torque, angular momentum, and rotational dynamics. Conservation of angular momentum. Rolling motion.

Properties of Matter: Elastic properties of solids: stress, strain, and Young's modulus.

Fluid mechanics: density, pressure, Pascal's principle, Archimedes' principle. Fluid dynamics: equation of continuity and Bernoulli's equation. Viscosity and surface tension.

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Heat and Thermodynamics: Temperature and thermal expansion. Heat transfer: conduction, convection, and radiation. First law of thermodynamics and its applications. Specific heats of gases. Second law of thermodynamics: entropy and Carnot engine.

Wave Optics (Introductory): Huygens' principle, interference, diffraction, and polarization. Applications in optical instruments.

Recommended Books:

1. Halliday, D., Resnick, R., & Walker, J. (2022). Fundamentals of Physics, 11th Edition; Wiley.
2. Young, H. D., & Freedman, R. A. (2019). University Physics with Modern Physics, 15th Edition; Pearson.
3. Giancoli, D. C. (2016). Physics: Principles with Applications, 7th Edition; Pearson.
4. Serway, R. A., & Jewett, J. W. (2020). Physics for Scientists and Engineers, 10th Edition; Cengage.
5. Tipler, P. A., & Mosca, G. (2007). Physics for Scientists and Engineers, 6th Edition; W.H. Freeman.

PHY- 303 Physics-II

Credit Hours: Three (3)

Objectives: Introduce the fundamental principles of electricity, magnetism, optics, and modern physics.

Strengthen analytical and problem-solving skills through conceptual and quantitative approaches.

Provide a foundation for advanced studies in physical sciences and engineering applications.

Course Contents:

Electrostatics: Electric charge and Coulomb's law. Electric field and electric flux. Gauss's law and its applications. Electric potential and potential energy. Capacitance and dielectrics.

Current Electricity: Electric current, resistance, and Ohm's law. Power and energy in electrical circuits. Series and parallel circuits. Kirchhoff's laws. RC circuits: charging and discharging.

Magnetism and Electromagnetic Induction: Magnetic field and magnetic force on a moving charge and current. Motion of charged particles in magnetic fields. Ampere's law and Biot–Savart law. Magnetic properties of materials. Faraday's law of induction and Lenz's law. Inductance and energy in magnetic fields.

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Electromagnetic Waves: Maxwell's equations (qualitative introduction). Generation and propagation of electromagnetic waves. Energy transport and the Poynting vector. Spectrum of electromagnetic waves and applications.

Geometrical and Physical Optics: Reflection and refraction at plane and spherical surfaces. Lenses, mirrors, and optical instruments. Interference: Young's double slit, thin films. Diffraction: single slit, diffraction grating. Polarization by reflection and polarizers.

Modern Physics: Failure of classical physics: blackbody radiation, photoelectric effect, and Compton effect. Bohr's model of the hydrogen atom. Wave–particle duality and de Broglie hypothesis. Basics of quantum mechanics: Schrödinger equation (qualitative), particle in a box. Nuclear physics: radioactivity, nuclear reactions, and applications.

Recommended Books:

1. Halliday, D., Resnick, R., & Walker, J. (2022). Fundamentals of Physics, 11th Edition; Wiley.
2. Young, H. D., & Freedman, R. A. (2019). University Physics with Modern Physics, 15th Edition; Pearson.
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