CURRICULUM FOR TWO-YEAR ASSOCIATE DEGREE / BS (4-YEAR) IN PHYSICS

DEPARTMENT OF PHYSICS
UNIVERSITY OF MALAKAND
2023- ONWARDS

Department of Physics
Chairman
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

BS (4-Year) in Physics

Degree Awarded: BS (4-year) in Physics

Entrance Requirements: HSSC (Pre-Engineering/Pre-Medical) or equivalent with at least 45% marks

Duration of the Program: 4 years (8 Semesters)

Semester Duration: 16-18 weeks

Total Credit Hours: **133**
Total Marks: **4400**

2-Year Associate Degree BS (2-Year) in Physics

Degree Awarded: Associate Degree BS (2-Year) in Physics

Entrance Requirements: HSSC (Pre-Engineering/Pre-Medical) or equivalent with at least 45% marks

Duration of the Program: 2 years (4 Semesters)

Semester Duration: 16-18 weeks

Total Credit Hours: **67**
Total Marks: **2100**

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The BS Scheme of Studies: Main Structure

S. No.	Categories	Requirement of HEC 2023 Policy (Credit Hours)	Number of Courses	Credit Hours
1	General Education Cluster	30	12	30
2	Interdisciplinary/Allied Courses	12	04	12
4	Major Courses + Laboratories	72	25	85
5	Project+ Internship	06	02	06
Total		**120**	**43**	**133**

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The BS Scheme of Studies: Layout/Framework

General Education Cluster		Allied Courses	
Title	**Credit hours**	**Title**	**Credit hours**
1. Pakistan Studies (Ideology and constitution of Pakistan)	**2**	**1.** Calculus I	**3**
2. Functional English	**3**	**2.** Astronomy	**3**
3. Quantitative Reasoning-I (Mathematics)	**3**	**3**. Ordinary Differential Equations	**3**
4. Quantitative Reasoning-II (Statistics)	**3**	**4**. Linear Algebra	**3**
5. Islamic Studies OR Ethics in lieu of Islamic studies for Non Muslim only	**2**		
6. Expository Writing	**3**		
7. Physical Chemistry (Natural Science)	**3**		
8. Social Sciences	**2**		
9. Arts and Humanities	**2**		
10. Civic and Community Engagement	**2**		
11. Applications of Information and Communication Technologies (ICT)	**2+1**		
12. Entrepreneurship	**2**		
Total	**30**	**Total**	**12**

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Major Courses		Capstone Project + Field Experience		Laboratories + Seminars	
Title	**Cr Hrs.**	**Title**	**Cr Hrs.**	**Title**	**Cr Hrs.**
1. Mechanics	**3**	**1.** Project	**3**	**1.** Laboratory I	**1**
2. Rotational Motion and Thermodynamics	**3**	2. Internship	**3**	**2.** Laboratory II	**1**
3. Electricity and Magnetism	**3**			**3.** Laboratory III	**1**
4. Waves and Optics	**3**			**4.** Laboratory IV	**1**
5. Modern Physics I	**3**			**5.** Laboratory V	**2**
6. Modern Physics II	**3**			**6.** Laboratory VI	**2**
7. Renewable Energy Resources	**3**			**7.** Laboratory VII	**2**
8. Basic Electronics	**3**				
9. Introductory Mathematical Methods for Physicists I	**3**				
10. Introductory Mathematical Methods for Physicists II	**3**				
11. Introductory Electrodynamics I	**3**				
12. Introduction to Electrodynamics II	**3**				
13. Introductory Classical Mechanics I	**3**				
14. Introductory Classical Mechanics II	**3**				
15. Introductory Statistical Physics I	**3**				
16. Introductory Statistical Physics II	**3**				
17. Introductory Quantum Mechanics I	**3**				
18. Introductory Quantum Mechanics II	**3**				
19. Solid State Physics I	**3**				
20. Solid State Physics II	**3**				
21. Nuclear Physics	**3**				
22. Atomic & Molecular Physics	**3**				
23. Elective I	**3**				
24. Elective II	**3**				
25. Elective III	**3**				
Total	**75**		**06**		**10**

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Scheme of Study for BS Physics (4-Year) Program

Any student with minimum of second division in HSSC or equivalent, with Physics, can get admission in BS Physics (4-Year) program.
The requirement for the BS degree in Physics is 133 credit hours of approved undergraduate courses. Out of these 133 credit hours, 91 credit hours are from Major Courses (Physics) the remaining credit hours comprises by 30 credit hours from General Education Cluster and 12 credit hours from Interdisciplinary/ Allied Course.

Scheme of Study for Associate Degree BS (2-Year) in Physics

Any student with minimum of second division in HSSC or equivalent, with Physics, can get admission in Associate Degree BS (2-Year) in Physics program.
The requirement for the Associate Degree BS (2-Year) in Physics is 67 credit hours of approved undergraduate courses. Out of these 37 credit hours, 91 credit hours are from Major/Allied Courses the remaining 30 credit hours comprise from General Education Cluster.

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Scheme of Studies for 2-Year Associate Degree/BS (4-Year) in Physics

Semester-I				
Codes	**Title of the Courses**	**Cr. Hrs.**	**Marks**	**Remarks**
ENG101	Functional English	3	100	General Education Cluster
PSC111	Ideology and Constitution of Pakistan	2	50	General Education Cluster
QR 101	Quantitative Reasoning-I (Mathematics)	3	100	General Education Cluster
PHYS101	Mechanics	3	100	Major Course
MATH121	Calculus-I	3	100	Allied Course
PHYS102	Rotational Motion & Thermodynamics	3	100	Major Course
PHYS101L	Lab-I	1	25	Major Course
The Teaching of Holy Quran with Translation		Non credit		
Fundamental of Mathematics For Medical Student (non credit compulsory should be passed)				
	Total	**18**	**575**	
Semester-II				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
ENG102	Introduction to Expository Writing	3	100	General Education Cluster
ISL112/ETH 118	Islamic Studies/ Ethics (for non Muslim)	2	50	General Education Cluster
QR 102	Quantitative Reasoning-II (statistics	3	100	General Education Cluster
PHYS103	Electricity and Magnetism	3	100	Major Course
PHYS104	Waves and Optics	3	100	Major Course
MGT215	Entrepreneurship	2	50	General Education Cluster
PHYS 103L	Lab-II	1	25	Major Course
The Teaching of Holy Quran with Translation		Non credit		

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	Total	**17**	**525**	

Codes	**Semester-III**			
	Title	**Cr Hrs**	**Marks**	**Remarks**
MATH328	Ordinary Differential Equations	3	100	Allied Course
PHYS201	Modern Physics-1	3	100	Major Course
PHYS202	Astronomy	3	100	Allied Course
SOC116	Introduction to Sociology	2	50	General Education Cluster
ISL 113	Seerah and its Contemporary Application سیرت رسول ﷺ اور اس کی عصری معنویت /Any course from Arts and Humanities in General Category (for non-Muslims)	2	50	General Education Cluster
SOC114	Civic and Community Engagements	2	50	General Education Cluster
PHYS201L	Lab-III	1	25	Major Course
The Teaching of Holy Quran with Translation		Non credit		
	Total	**16**	**475**	

Semester-IV				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
GEOL101/ CHEM 110/ BOT 112	Introduction to Geology/ Chemistry in everyday life/ Plant Sciences	3	100	General Education Cluster
MATH327	Linear Algebra	3	100	Allied Course
CS110	Introduction to Information and Communication Technologies	2+1	100	General Education Cluster
PHYS202	Modern Physics-II	3	100	Major Course
PHYS203	Renewable energy resources	3	100	Major Course
PHYS 203L	Lab-IV	1	25	Major Course
The Teaching of Holy Quran with Translation		Non credit		

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	Total	**16**	**525**	

Semester-V				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
PHYS351	Classical Mechanics I	3	100	Major Course
PHYS352	Electrodynamics I	3	100	Major Course
PHYS353	Statistical Mechanics I	3	100	Major Course
PHYS354	Mathematical Methods for Physicists I	3	100	Major Course
PHYS355	Basic Electronics	3	100	Major Course
PHYS301L	Lab-V	2	50	Major Course
The Teaching of Holy Quran with Translation		Non credit		
	Total	**17**	**550**	

Semester-VI				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
PHYS361	Classical Mechanics II	3	100	Major Course
PHYS362	Electrodynamics II	3	100	Major Course
PHYS363	Statistical Mechanics II	3	100	Major Course
PHYS364	Mathematical Methods for Physicists II	3	100	Major Course
PHYS365	Quantum Mechanics I	3	100	Major Course
PHYS366L	Lab-VI	2	50	Major Course
The Teaching of Holy Quran with Translation		Non credit		
	Total	**17**	**550**	

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Semester-VII				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
PHYS471	Solid State Physics I	3	100	Major Course
PHYS472	Atomic and Molecular Physics	3	100	Major Course
PHYS473	Nuclear Physics	3	100	Major Course
PHYS474	Quantum Mechanics II	3	100	Major Course
PHYS475L	Lab-VII	2	50	Major Course
PHYS499	Internship	3	100	Field Experience
The Teaching of Holy Quran with Translation		Non credit		
	Total	**17**	**550**	

Semester-VIII				
Codes	**Title of the Courses**	**Cr Hrs**	**Marks**	**Remarks**
PHYS481	Solid State Physics II	3	100	Major course
PHYS4XY	Elective I	3	100	Major course
PHYS4XY	Elective II	3	100	Major course
PHYS4XY	Elective III	3	100	Allied Course
PHYS500	Project	3	100	Capstone Project
The Teaching of Holy Quran with Translation		Non credit		
	Total	**15**	**500**	

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

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ELECTIVE COURSES

S. No	Course Code	Course Name	Credit hours
1.	PHYS-482	Particle Physics	03
2.	PHYS-483	Plasma Physics	03
3.	PHYS-484	Surface Physics	03
4.	PHYS-485	Fluid Dynamics	03
5.	PHYS-486	Methods of Experimental Physics	03
6.	PHYS-487	Environmental Physics	03
7.	PHYS-488	Quantum Information and Quantum Computation	03
8.	PHYS-489	Semiconductor Physics	03
9.	PHYS-490	Computer Simulation	03
10.	PHYS-491	Digital Electronics	03
11.	PHYS-492	Experimental Nuclear Physics	03
12.	PHYS-493	Laser Physics	03
13.	PHYS-494	Fundamentals of Optoelectronics	03
14.	PHYS-495	Introduction to Material science	03
15.	PHYS-496	Introduction to Nano Science	03
16.	PHYS-497	Quantum Optics	03
17.	PHYS-498	Seminar	01
18.	PHYS-499	Internship	03
19.	PHYS-500	Project	03

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DETAILS OF ALLIED AND MAJOR COURSES FOR BS (4-Year) PROGRAM

MATH-121 Mathematics-I (Calculus-I) Cr. Hrs: 3

Specific Objectives of the Course:

Calculus is serving as the foundation of advanced subjects in all areas of mathematics. The course, equally, emphasizes the basic concepts and skills needed for mathematical manipulation. This course focuses on the study of functions of a single variable.

Course Outline:

Functions, upper and lower bounds of variables and functions, inverses of exponential, circular, hyperbolic and logarithmic functions, one sided and two sided limits of functions, continuity of functions and their graphical representations, properties of continuous function on closed bounded intervals, discontinuity of function and its types. Derivatives: Definition, techniques of differentiation. Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions, Inverse functions and their derivatives. 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. Mean value theorems. Indeterminate forms and L'Hopitals rule. Anti-derivatives and integrals. Riemann sums and the definite integral. Properties of Integral. The fundamental theorem of calculus. Various techniques of integration. Reduction formulae and use of Gamma Beta Functions for integral.

Recommended Books:

1. J. Stewart, *Calculus* (5th edition or latest edition), Brooks/ Cole, 2002.
2. H. Anton, I. Bevens, S. Davis, *Calculus: A New Horizen* (8th edition or latest), John Wiley, New York, 2005.
3. G. B. Thomas, A. R. Finney, *Calculus* (11th edition or latest edition), Addison-Wesley, Reading, Ma, USA, 2005.

PHYS-101 Mechanics Cr.Hrs: 03

Course Objectives:

This course is based on basic concepts of physics that will enable students to understand fundamentals of mechanics. After studying this course students will be able to solve problems related to physics/mechanics.

Course Outline:

Motion along a straight line (position, displacement, velocity, acceleration and graphical analysis of motion). Vectors and their components (vectors, unit vectors, vectors addition by components, multiplication of vectors). Motion in two and three dimensions (position, velocity etc. projectile motion, uniform circular motion, relative motion in one and two dimensions). Force and Motion-I (Newton's laws, applying Newton's laws, some

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particular forces). Force and Motion-II (Friction, Drag force and terminal speed, Uniform circular motion). Kinetic Energy and Work (work done and Kinetic energy, work done by gravitational force, Work done by a spring and variable force, Power). Potential Energy and Conservation of Energy (Potential energy, conservation of mechanical energy, potential energy curve, Work done on a system by external force). Center of mass and linear momentum(center of mass, Newton's second law for a system of particles, linear momentum, Collision and impulse, Conservation of linear momentum, Momentum and kinetic energy in collision, elastic collision in one and two dimensions, systems with varying mass

Text Book: Fundamentals of Physics by Halliday, Resnick and Walker: 8th Edition (Text book).
Holiday, Resnik, Krane
Serway Jewett, Physics for Scientists and Engineers with Modern Physics. (2010)

Recommended Book:
University Physics with Modern Physics 13th Ed. Pearson Education Inc. USA

PHYS-102 Rotational Motion and Thermodynamics Cr.hr: 03

Course Objectives:

This course is based on basic concepts of physics that will enable students to understand fundamentals of rotational mechanics and thermodynamics. After studying this course students will be able to solve related problems.

Course Outline:

Rotation with Constant Angular Acceleration, Relating the Linear and Angular Variables, Kinetic Energy of Rotation, Calculating the Rotational Inertia, Torque, Newton's Second Law for Rotation, Work and Rotational Kinetic Energy, Rolling as Translation and Rotation Combined, The Kinetic Energy of Rolling, The Forces of Rolling, Angular Momentum, Newton's Second Law in Angular Form, The Angular Momentum of a System of Particles, The Angular Momentum of a Rigid Body Rotating About a Fixed Axis, Conservation of Angular Momentum, Newton's Law of Gravitation, Gravitation and the Principle of Superposition, Gravitation Near Earth's Surface, Gravitation Inside Earth, Gravitational Potential Energy, Planets and Satellites, Kepler's Laws, Satellites: Orbits and Energy, Einstein and Gravitation, A Closer Look at Heat and Work, The First Law of Thermodynamics, Some Special Cases of the First Law of Thermodynamics, Heat Transfer Mechanisms, Avogadro's Number, Ideal Gases, Pressure, Temperature, and RMS Speed, Translational Kinetic Energy, Mean Free Path, The Distribution of Molecular Speeds, The Molar Specific Heats of an Ideal Gas, Degrees of Freedom and Molar Specific Heats, A Hint of Quantum Theory, The Adiabatic Expansion of an Ideal Gas, Irreversible Processes and Entropy, Change in Entropy, The Second Law of Thermodynamics, Entropy in the Real World: Engines, Entropy in the Real World: Refrigerators, The Efficiencies of Real Engines, A Statistical View of Entropy

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Text Book: Physics by Hallidy, Resnick and Walker: 8th Edition

PHYS-101L Lab-I (Mechanics) **Cr.Hrs: 1**

Objectives:

The purpose of the introductory physics lab is to supply the practical knowledge for understanding of the basics physics experiments.

Experiments:

1. Modulus of Rigidity by Static & Dynamic method (Maxwell's needle, Barton's Apparatus).
2. Measurement of viscosity of liquid by Stoke's / Poiseulli'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 thermal Emf and plot temperature diagram.
9. Determination of temperature coefficient of resistance of a given wire.
10. Determination of "J" by Callender – Barnis method.
11. The determination of Stefan's constant.
12. Calibration of thermocouple by potentiometer.
13. To determine the Thermal conductivity of good and bad conductors using Lee's and Searl's apparatus.
14. To determine Horizontal/Vertical distance by Sextant.

Recommended Books:

1. D. H. Marrow, Selected Experiments in Physical Sciences, Longman.
2. Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
4. C. K. Bhattacharya, University Practical Physics, CBS Publishing

Fundamental Mathematics **Cr.Hrs: 03**

Trigonometry, complex numbers, vector algebra, ordinary differentiation, ordinary integration, limits and continuity, binomial theorem, Taylor series, probability, group theory

Text Book: S. Lang, Basic Mathematics Columbia University, Addison-Wesley Publishing Company, Inc. New York

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PHYS-103 Electricity and Magnetism **Cr.Hrs: 03**

Electrostatics: Electric Charge, Quantization and conservation of electric charge, Coulomb's Law, Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to a Charge Distribution, Electric Dipole in an Electric Field, Electric Flux, Gauss' Law and its Applications in Planar, Spherical and Cylindrical Symmetry

Electric Potential: Equipotential Surfaces, Potential due to a Point Charge and a Group of Point Charges, Potential due to an Electric Dipole, Potential due to a continuous Charge Distribution, Relation between Electric Field and Electric Potential Energy,

Capacitors and Capacitance: Parallel Plate, Cylindrical and Spherical capacitors, Capacitors in Series and Parallel, Energy Stored in an Electric Field, Dielectrics and Gauss' Law

DC Circuits: Electric Current and Current Density, Resistance and Resistivity, Ohm's Law, Power in Electric Circuits, Work, Energy, and EMF, Resistances in Series and Parallel, Single and Multiloop Circuits, Kirchhoff's Rules, RC Circuits, Charging and Discharging of a Capacitor

Magnetic Field and Magnetic Force: Crossed Electric and Magnetic Fields and their Applications, Hall Effect, Magnetic Force on a Current Carrying Wire, Torque on a Current Loop, Magnetic Dipole Moment, Magnetic Field Due to a Current, Force between two Parallel Currents, Ampere's Law, Biot-Savart Law: Magnetic Field due to a Current, Long Straight Wire carrying Current, Solenoids and Toroids, A current-carrying Coil as a Magnetic Dipole, Inductance, Faraday's Law of Induction, Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductances, Self Inductance, RL Circuits, Energy Stored in a Magnetic Field, Energy Density, Mutual Induction, Transformers

Recommended Text 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

PHYS-104 Waves and Optics **Cr. Hrs: 03**

Course Objectives:

To obtain a sound understanding of oscillations and waves and their mathematical description. To acquire the basic knowledge of EM waves and optical phenomena such as interference, diffraction and polarization

Course Outlines:

Simple harmonic motion, angular simple harmonic oscillator, simple pendulum and physical pendulum, simple harmonic motion and uniform circular motion, damped simple

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harmonic motion, forced oscillations and resonance, transverse and longitudinal waves, waves on a stretched string, energy and power of a wave traveling along a string, the wave equation, interference of waves, phasors, standing waves and resonance, sound waves, speed of sound waves, interference of sound waves, intensity of sound, sound level and the Decibel scale, standing waves in pipes, beats, the Doppler effect.

Electromagnetic waves, polarization of EM waves, reflection and refraction of light, total internal reflection, plane mirrors and spherical mirrors, the mirror equation, magnification, thin lenses, the lens maker's equation, light waves, index of refraction, interference of light waves and Young's interference experiment, intensity in double-slit interference, interference from thin films, diffraction of light waves, single-slit diffraction, intensity in single-slit diffraction, diffraction by a circular aperture, double-slit diffraction, diffraction gratings, dispersion and resolving power.

Recommended Books:

1. Fundamentals of Physics by Halliday, Resnick and Walker, 10th Edition.
2. Physics Vol. I & II by Resnick, Halliday and Krane, 5th Edition, John Wiley and Sons Inc, New York, 2002.
3. L. S.. Pedrotti, S. Pedrotti and L. M. Pedrotti, "Introduction to Optics", Pearson Prentice Hall, 3rd ed. (2007).
4. University Physics 8th Edition by Sears, Zemansky and Young, Addison-Wesley, Reading (MA), USA, 2000.

PHYS-103L Lab-II (Electricity and Magnetism) Cr.Hrs: 1

1. Measurement of resistance using a Neon flash bulb and condenser
2. Conversion of a galvanometer into Voltmeter & an Ammeter
3. Calibration of an Ammeter and a Voltmeter by potentiometer
4. Charge sensitivity of a ballistic galvanometer
5. Comparison of capacities by ballistic galvanometer.
6. Measurement of low resistance coil by a Carey Foster Bridge.
7. Resonance frequency of an acceptor circuit
8. Resonance frequency of a Rejecter Circuit.
9. Study of the parameter of wave i.e. amplitude, phase and time period of a complex signal by CRO.
10. Measurement of self/mutual inductance.
11. To study the application of Lorentz force by CRO.

Recommended Books:

1. D. H. Marrow, Selected Experiments in Physical Sciences, Longman.
2. Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
4. C. K. Bhattacharya, University Practical Physics, CBS Publishing

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Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-IAzam University Islamabad, Punjab University.

MATH- 328 Differential Equations **Cr Hrs: 03**

Specific Objectives of the Course:

This course will provide the foundation for all advanced subjects in Mathematics. Strong foundation and applications of Ordinary Differential Equations is the goal of the course.

Course Outline:

Basic definition of differential equations, formation of differential equations, initial and boundary value problems, differential equations of the first order and first degree, equations with separable variable, homogeneous differential equations, equations reducible to homogeneous form, exact differential equations, integrating factors, rules for determinations of integrating factors, linear equations of the first order, Non-linear equations of the first order, linear differential equations of high order, solution of homogeneous linear equations, principle of superposition and Wronksian, determination of particular integral, short methods for finding particular integral, orthogonal trajectories, Cauchy-Euler equations, 2^{nd} order linear differential equations, reduction of order method, undetermined Coefficient method, variations of parameters method.

Recommended Books:

1. D.G. Zill, M.R, Cullen, Differential Equations withBoundary-Value Problems, (latest Edition), PWS Publishing Company, 2010.
2. D.G. Zill, Advanced Engineering Mathematics, Jones and Bartlett Publishers, 2005.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons (9^{th} edition), 2010.
4. G.E. Andrews, R. Askey, and R. Roy, Special Functions, Cambridge University Press, 2000.

PHYS-201 Modern Physics I **Cr.Hrs: 3**

Course Objectives

Modern physics is serving the foundation of advanced subjects in physics. The course emphasizes to learn the basic concepts of symmetry of the nature to understand the non-classical aspects of the Physics.

Course Contents

Frame of references, postulates of special relativity, time dilation and length contraction, ultimate speed limit, relativistic mass and momentum, relativistic second law, relativistic and rest mass energy, relativistic energy and momentum, massless particles, Galilean and Lorentz transformation , Inverse transformation, Lorentz velocities addition, simultaneity, space time interval, light cones, time like, space like and light like intervals, Electromagnetic waves, black body radiations, Stefan Boltzmann law, Wien displacement and Wien fifth law, Rayleigh Jean law, Plank radiation law, X-rays and their types, Production of x-rays, Photoelectric effect, Compton effect, De-Broglie waves, Davisson

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and Germer as well as G.P Thomson experiments for electron diffraction, nuclear atom, Rutherford experiment and scattering formula, electron orbits, atomic spectra, quantization in atomic world, correspondence principle, Franck-Hertz experiment, Laser, Ruby and Helium-Neon lasers schemes, quantum numbers, space quantization,

Text Books:

(1) Concepts of Modern physics (latest edition) by Arthur Beiser
(2) Introduction to Atomic and Nuclear physics (HENRY SEMAT)
(3) R.A. Serway, C.J. Moses, C.A. Moyer, "Modern Physics", Brooks Cole, 3rd edi. 2004.
(4) P. A. Tipler and R.A. Llewellyn "Modern Physics" W H Freeman and Company 6th ed. 2012.

PHYS-202 Astronomy **Cr.Hrs. 03**

Objective of the course

In this introductory course the students will learn how theoretical research with observations has led to our present understanding of astronomical bodies. While continuing their education, students can use the knowledge gained in the Astronomy course to allow them to put in perspective mankind's place in the universe.

Outlines

Introductory Concepts, Orbits & Light, Spectroscopy, Telescopes, Solar System, Planetary System Formation, The Sun, Properties of Stars, Interstellar Medium, Star Formation, Stellar Evolution, Stellar Explosions, Neutron Stars, Cosmology Cosmology and the Early Universe, Gamma-ray, Bursts & Black Holes, Milky Way, Galaxies, The Early Universe

Text Books:

1. "Astronomy" Fraknoi, A et al. University of San Francisco. ISBN-13: 978-1-711470-56-6
2. "Cosmic Perspective, The Solar System", by Bennett & Donahue, Addison Wesslley, 5th Ed. paperbk.
3. "A Beginners Guide to the Universe" 7th Ed., Chaisson and McMillan, 2013, Pearson Education Inc. (Glenview, Il). ISBN 978-0-321-81535-4.
4. "Universe" by Freedman & Kaufmann, Freeman, 8th Ed.

PHYS-201L Lab-III (Waves and Optics) **Cr. Hrs: 1**

1. Investigation of phase change with position in traveling wave and measurement of the velocity of sound by C.R.O.
2. To study the damping features of an oscillating system using simple pendulum of variable mass
3. To determine frequency of AC supply by CRO.
4. The determination of wavelength of Sodium –D lines by Newton's Ring.

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5. The determination of wavelength of light/laser by Diffraction grating.
6. Determination of wavelength of sodium light by Fresnel's bi-prism.
7. The determination of resolving power of a diffraction grating.
8. The measurement of specific rotation of sugar by Polarimeter and determination of sugar concentration in a given solution.
9. To study the combinations of harmonic motion (Lissajous figures).
10. To study the parameters of waves (Beats phenomenon).
11. To study the laws of vibration of stretched string using sonometer.

Recommended Books:

1. D. H. Marrow, Selected Experiments in Physical Sciences, Longman.
2. Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
4. C. K. Bhattacharya, University Practical Physics, CBS Publishing

Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-IAzam University Islamabad, Punjab University.

MATH-327 Linear Algebra **Cr Hrs: 03**

Specific Objectives of the Course:

This is a course in abstract linear algebra. The majority of follow up courses in both pure and applied mathematics assume the material covered in this course.

Course Outline: Algebra of matrices, determinants, matrix of a linear transformation, row and column operations, rank, inverse of matrices, solution of homogeneous and non-homogeneous equations, orthogonal transformation. Vector spaces, subspaces, linear dependence and independence, linear span of a subset of a vector space, bases and dimensions of a vector space, sums and direct sums of subspaces of a finite dimensional vector space, dimension theorem, linear transformation, null space, image space of linear transformation, rank and nullity of a linear transformation, relation between rank, nullity and dimension of the domain of a linear transformation, matrix of linear transformation, change of basis, inner product spaces, orthogonal and orthonormal basis, similar matrices and diagonalization of a matrix, Home (V,W), dimension and basis of Home (V,W), dual space and dual basis, annihilators, Eigen values and Eigen vectors and minimal polynomials.

Recommended Books:

1. S. J. Axle, Linear Algebra Done Right, *Undergraduate Texts in Mathematics*, Springer, New York, Schaum's outlines series, 1996.
2. G. Birkhoff, S. Maclane, *A Survey of Modern Algebra* (4th edition), AKP, 1998.
3. W. L. C. Perry, *Elementary Linear Algebra*, McGraw-Hill, New York, 1988.

PHYS-202 Modern Physics II **Cr. Hrs: 3**

Course Objectives

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Modern physics is serving the foundation of advanced subjects in physics. The course emphasizes to learn the concepts of symmetry of the nature to understand the non-classical aspects of the Physics.

Course Contents

Introduction to statistical mechanics, statistical distribution, Classical Maxwell Boltzmann statistics, Molecular energies distribution in ideal gas, distribution of molecular speeds, Root mean square speed, average and most probable speeds, Quantum statistics, bosons and fermions, symmetric and anti-symmetric waves functions, Bose- Einstein and Fermi Dirac distributions, Bose-Einstein condensation, specific heats of solid, Dulong-Petit law and Einstein formula for specific heat capacity, Free-electron in metals, electron energy distribution and Fermi energy, Solid state physics, crystalline and amorphous solids, crystal defects, ionic crystals, cohesive energy of ionic crystal, covalent crystals, Bucky ball and nano-tubes, Van der Walls bonds, Hydrogen bonds, metallic bonds and metallic hydrogen, band theory of solids, formation of valence and conduction bands in carbon and silicon, Insulator, semiconductor and conductor, Nuclear structure, Nuclear composition, Atomic masses, nuclear properties, nuclear decays, Binding energy, binding energy per nucleon, nuclear models, strong nuclear forces, meson theory of nuclear forces, radioactive decay, Half-life and radiometric dating, radioactive series, alpha, beta and gamma decays, nuclear reactions and its types, Nuclear fission and nuclear fusion, Flavor, Higgs boson, The standard model.

Text Books:

(1) Concepts of Modern physics (latest edition) by Arthur Beiser
(2) Introduction to Atomic and Nuclear physics (HENRY SEMAT)
(3) R.A. Serway, C.J. Moses, C.A. Moyer, "Modern Physics", Brooks Cole, 3rd Ed. 2004.
(4) P. A. Tipler and R.A. Llewellyn "Modern Physics" W H Freeman and Company 6th ed. 2012.

PHYS-204 Renewable Energy Resources Cr.Hrs: 3

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

Outlines:

Energy Scenarios: Importance of energy, world primary energy sources, energy demand, supplies, reserves, growth in demand

Energy & Environment: Emission of pollutants from fossil fuels and their damaging effects, and economics impact; Renewable energy and its sustainability. Promising renewable energy sources,

Solar Energy: Sun-Earth relationship, geometry, sun path and solar irradiance, solar spectrum, solar constant, atmospheric effects, global distribution, daily and seasonal variations

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:

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Photovoltaic: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, power, spectral response, fill-factor, temperature effect; PV systems, 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,

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;

Biogas: Biomass sources; residue, farms, forest. Solid wastes: agricultural, industrial and municipal wastes etc; applications, Environment issues.

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

Waves and Tides: Wave motion, energy, potentials, sites, power extraction, and transmission, generation of tides,

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,

Recommended Books

1. World Energy Supply: Resources, Technologies, Prospectives: Manfred Grathwohl; Walter deGruyter – Berlin, 1982.
2. Renewable Energy Resources; John W. Twidell and Anthony D. Weir; E & F.N. Spon Ltd. London. 1986.
3. An Introduction to Solar Radiation: Muhammad Iqbal; Academic Press, Canada. 1983.
4. A Practical Guide to Solar Electricity, Simon Roberts: Prentice Hall Inc. USA, 1991.

PHYS-202L Lab-IV (Modern Physics) Cr. Hrs: 1

Objectives:

The laboratory should engage each student in significant experiences with experimental processes, including some experience designing investigation. The aim of this lab is to make students able to get understanding about electronic devices including gates, transistors, capacitors, diodes etc and aware them about their importance in real world systems.

1. Determination of Planck's constant (h) by using the photoelectric effect.
2. Determination of the charge on an electron (e) by Millikan's method.
3. The Frank-hertz experiment (Measurement of excitation potential of Hg).
4. Determination of the Rydberg constant from the spectrum of hydrogen.
5. Fabry-Perot interferometer used as a gas refractometer.
6. To study the Zeeman effects for a line in the spectrum of helium.
7. To prove the Rutherford law of scattering of charged particles and study of their

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Photoelectric effect and Compton absorption

8. Determination of ionization potential of mercury.
9. To find the stopping potential of photo cell

Recommended Books:

1. G L Squires, Practical Physics, 3rd Edition, Cambridge University Press
2. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
3. C K Bhattacharya, University Practical Physics, CBS Publishing.

Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-e-Azam University Islamabad, Punjab University.

PHYS-351 Classical Mechanics I Cr.Hrs: 3

Prerequisite: Mechanics

Introduction

Newtonian mechanics: Space and Time, Newton's laws, Frame of Reference, The equation of motion for a particle, Conservative Theorems, Energy, Limitations of Newtonian mechanics.

Oscillations: Simple harmonic oscillator, harmonic oscillations in two dimensions, Phase diagrams, damped oscillations, sinusoidal deriving forces, physical systems, principle of superposition.

Some methods in calculus of variations: Statement of the problem, Euler's equation, The second form of the Euler equation, functions with several dependent variables, Euler equations when auxiliary conditions are imposed, the δ notation.

Hamilton's principle, Lagrangian and Hamiltonian dynamics: Hamilton's principle, applications of Hamilton's principle, generalized coordinates, Lagrange's equations of motions in generalized coordinates, Lagrange's equations with undermined multipliers, Equivalence of Lagrange's and Newton's equations, Essence of Lagrange's dynamics, a theorem concerning the kinetic energy, Conservation theorems revisited, Canonical equations of motion, Hamiltonian dynamics and some comments regarding dynamical variables and variational calculations in physics, phase space and Liouville's theorem, Virial theorem, applications of Virial theorem.

Central force motion: Reduced mass, conservation theorems, first integrals of the motion, equation of motion, orbits in a central field, centrifugal energy and effective potential, Planetray motion and Kepler's problem, orbital dynamics, apsidal angles and precession, stability of circular orbits.

Recommended Book:

1. S.T. Thornton, J.B. Marion, “Classical Dynamics of Particles and Systems”, Brooks Cole; 5th ed. (2003).
2. T. L. Chow, “Classical Mechanics”, John Wiley, (1995).
3. H. Goldstein “Classical Mechanics” latest edition.

PHYS-352 Electrodynamics I Cr.Hrs: 3

Objectives: To prepare the students regardingthe concepts of electrodynamics, the basic laws of electrodynamics, electric filed, potential and use of them in various situations.

Course contents:

Vector Analysis, Vector Algebra, Differential calculus, integral calculus Curvilinear coordinate, The Dirac delta functions, The Theory of Vector Fields.

Electrostatics, The Electric Field, Divergence and Curl of Electrostatic field, Electric Potential, Work and Energy in Electrostatics, Conductors.Special Techniques, Laplace's Equation, The Method of Images, Separation of Variables, Multipole, Expansion. Electric Fields in MatterPolarization, The Field of a Polarized Objects, The Electric Displacement, Linear Dielectrics. Magnetostatics, The Lorentz force law, The Biot Savart Law, The Divergence and Curl of B, Magnetic Vector Potential.

Text book: Introduction to Electrodynomics (4^{th} Edition) by David J. Griffiths).

Recommended Books:

1. Electromagnetic Theory by Carson and Lorains
2. Electromagnetic Theory by Reid and Milford.

PHYS-353 Statistical Mechanics I Cr.Hrs: 03

Fundamental definitions, Thermometers, Different aspects of equilibrium, Mechanical equilibrium, Thermal equilibrium, Chemical equilibrium, Functions of state, Internal energy, Reversible changes, Enthalpy, Heat capacities, Reversible adiabatic changes in an ideal gas, work done in various thermodynamic process, A first look at the entropy, The second law of thermodynamics, The Carnot cycle, The equivalence of the absolute and the perfect gas scale of+ temperature, Definition of entropy, Measuring the entropy, The law of increase of entropy, Calculations of the increase in the entropy in irreversible processes, Two systems at different temperatures thermalize, Extending a spring, Expanding a gas into a vacuum, The approach to equilibrium ,Ideas about probability, Classical probability, Statistical probability, The axioms of probability theory, Independent events, Counting the number of events, Arrangements, Permutations of r objects from *n*, Combinations of r objects from *n*, Statistics and distributions (Binomial distribution, Gaussian distribution and poison distribution, error function),Introduction, Micro canonical ensemble, Definition of the quantum state of the system, A simple model of spins on lattice sites, Equations of state, Spin system, Vacancies in a crystal, A model for a rubber band, The second law of thermodynamics, A system in contact with a heat bath, The partition function, Definition of the entropy in the canonical ensemble, The bridge to thermodynamics through the partition function, The condition for thermal equilibrium, Thermodynamic quantities from partition function, Two-level system, Single particle in a one-dimensional box, Single particle in a three-dimensional box, Expressions for heat and work, Rotational energy levels for diatomic molecules, Vibrational energy levels for diatomic molecules, Factorizing the partition function, Equipartition theorem, Minimizing

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the free energy (Minimizing the Helmholtz free energy, Minimizing the Gibbs free energy).

Text Book.

Roger Bowley and Mariana Sanchez, "Introductory Statistical Mechanics", Clarendon Press Oxford, second edition 1999.

Reference Books

1. Harvey Gould and Jan Tobochnik, "Statistical and Thermal Physics with Computer Application",
, second edition 2010.
2. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Press Inc. 2008

PHYS-354 Mathematical Methods for Physicists I Cr.Hrs: 3

Objectives The objectives of this course is to develop the skills for mathematical physics involving power series, complex numbers, matrix operations, implicit differentiation, optimization, and analysis for complex functions.

Course Outline:

The geometric series, convergent and divergent series, testing series for convergence; the preliminary test, convergence test for series of positive terms; absolute convergence, alternating series, power series; interval of convergence, power series, accuracy of series approximation. complex plane, complex algebra, complex infinite series, complex power series; disk of convergence, powers and roots, exponential and trigonometric functions, hyperbolic functions, applications. matrices; row reduction, determinants; cramer's rule, vectors, lines and planes, matrix operations, linear combinations, linear functions, linear operators, linear dependence and independence, special matrices and formulas, diagonalizing matrices, power series in two variables, approximations using differentials, chain rule or differentiating a function of a function, implicit differentiation, more chain rule, application to maximum and minimum problems. analytic functions, contour integrals, the residue theorems, methods of finding residues, evaluation of definite integrals by use of residue theorem.

Recommended Books:

1. Mary L. Boas Mathematical Methods In The Physical Sciences Third Edition.
2. Mathematical Methods for Physicists*:* by Arfken & Weber, publisher: Academic Press; 6th Edition, (2005)
3. Mathematical Methods for Physicists: by Tai L. Chow, publisher: Cambridge University Press, (2002).

PHYS-355 Basic Electronics Cr.Hrs: 3

Course Objectives: To enable students to understand basics electronics, electrical circuits and their applications.

Course Contents: Ohm's law, Kirchoff's voltage and current laws, the superposition principle, multi-path circuits. Source transformation, maximum power transfer theorem, Thevenin-Norton equivalent circuits, linear system analysis basics. Introduction to

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semiconductors, intrinsic and extrinsic semiconductors, temperature dependence of carrier concentrations, electrons and holes. Basic principles of pn junctions, built-in potential, and space charge layers, forward and reverse bias, the diode equation. Ideal diodes, terminal characteristics of junction diodes, modeling the diode forward characteristic, operation in the reverse breakdown region. Rectifier circuits, limiting and clamping circuits, special diodes (Zener and tunnel diodes) and applications. Fully controlled single phase SCR bridge rectifier and rectifier circuits, switch mode power supplies. Bipolar Junction Transistors (BJT), device structure and physical operation, current-voltage characteristics, DC analysis and biasing techniques, small-signal operation and models, single stage amplifier, transfer functions, BJTs as a switch. Basic operational amplifiers, inverting and non-inverting, differential modes, gain and bandwidth, frequency response, nonlinear applications. Principles of feedback, stability, oscillator circuits, analysis in real time and frequency space.

Recommended texts:

1. Microelectronic Circuits, by A.S. Sedra and K.C. Smith, publisher: Oxford University Press, 5th Edition (2007).
2. Thomas L. Floyd, Electronic Devices (Conventional Current Version), 9th edition, 2012, Pearson.
3. Semiconductor Physics and Devices, by DS. A. Neamen, publisher: McGraw – Hill Science/Engineering/Math, 3rd Edition (2002)
4. Electrical Circuit Theory and Technology, by J. O. Bird, publisher: Newnes (an Imprint of Butterworth – Heinemann Ltd), 2nd Revised Edition (2003).

PHYS-301L Lab- V (Electronics) Cr.Hrs: 2

Objectives:

The laboratory should help the students to develop a broad array of basic skills and tools of experimental physics and data analysis. The aim of this lab is to give the students the experimental techniques and physical understanding of nuclear phenomena.

1. Transistor pulse-circuitry (three types of flipflop and the Schmidt trigger circuit).
2. Design of high or medium voltage dc power supply and measurement of the voltage regulation. Ripple factor etc.
3. Design of an L.F.R.C. coupled amplifier and a study of its characteristics.
4. Design of high or medium voltage dc power supply and measurement of the voltage regulation. Ripple factor, etc.
5. Design of a medium wave T.R.F. or superheterdyne receiver and measurement of its sensitivity. Power out-put selectivity, etc. the operational amplifier.
6. To design and build a linear integrator to enable digitization of photo-multiplier pulses, or to design and build a height-to-width converter.
7. To design and build a lotic circuit (using AND/OR/NOR gates) for performing a given function.
8. Setting up of half & full wave rectifier & study of following factors

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i. Smoothing effect of a capacitor
ii. Ripple factor & its variation with load.
iii. Study of regulation of output voltage with load.

9. To set up a single stage amplifier & measure its voltage gain and bandwidth.
10. To set up transistor oscillator circuit and measure its frequency by an oscilloscope.
11. To set up and study various logic gates (AND, OR, NAND etc) using diode and to develop their truth table.
12. To set up an electronic switching circuit using transistor LDR and demonstrate its use as a NOT Gate.
13. Characteristics of a transistor.
14. Study of electric circuits by black box.
15. To study the network theorems (Superposition, Thevinin, Norton).

Recommended Books:

1. R.J. Higgings. Experimental Electronics (McGraw-Hill).
2. G. L. Squires, Practical Physics, 3rd Edition, Cambridge University Press
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
4. C. K. Bhattacharya, University Practical Physics, CBS Publishing.

Study Tour: A study tour may be arranged for students to various Physics Research Institutes/Centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-IAzam University Islamabad, Punjab University.

PHYS-361 Classical Mechanics II **Cr.Hrs: 3**

Prerequisite: Classical Mechanics I

Dynamics of a system of particles: Centre of mass, Linear momentum of the systems, angular momentum of the systems, energy of the system, elastic collisions of two particles, kinematics of elastic collisions, inelastic collisions, scattering cross sections, Rutherford scattering formula, rocket motion.

Motion in a noninertial reference frame: Rotating coordinates systems, centrifugal and Coriolis forces, motion relative to earth.

Dynamics of rigid bodies: Simple planar motion, inertia tensor, angular momentum, principal axes of inertia, moments of inertia for different coordinate systems, further properties of the inertia tensor, Eulerian angles, Euler's equations for a rigid body, force-free motion of a symmetric top, motion of a symmetric top with one point fixed, stability of rigid body rotations.

Special theory of relativity: Galilean invariance, Lorentz transformation, Experimental verification of the special theory, Relativistic Doppler effect, twin paradox, relativistic

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momentum, energy, space time and four vectors, Lagrangian function in special relativity, relativistic kinematics.

Recommended Book:

1. S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; 5th ed. (2003).
2. T. L. Chow, "Classical Mechanics", John Wiley, (1995).
3. H. Golstein "Classical Mechanics" latest edition..

PHYS-362 Electrodynamics II Cr.Hrs: 3

Objectives: To apprise the students regarding the concepts of electrodynamics, Maxwell's equations, electromagnetic waves and their use in various situations.

Course contents: Magnetic Fields in Matter, Magnetization ,The Field of Magnetized Object, The Auxiliary Field H., Linear and, Non Linear Media, Electrodynamics, Electromotive Force**,** Electromagnetic Induction**,** Maxwell's Equations**,** Conservation Laws, Charge and Energy, Momentum, Electromagnetic Waves, Waves in one dimension,Electromagnetic waves in vacuum, Electromagnetic waves and matter, Absorption and dispersion**,** Guided waves**,** potential and Fields, the potential formulation, Continues distribution, Point Charges

Text book: Introduction to Electrodynamics (Latest Ed.) by David J. Griffiths.

Recommended Books:

1. Electromagnetic Theory by Carson and Lorains. Latest Ed.
2. Electromagnetic Theory by Reid and Milford. Latest Ed.
3. Classical Electrodynamics by S. P. Puri Tata McGraw Hill 1999

PHYS-363 Statistical Mechanics II Cr.Hrs: 3

Identical particles, Symmetric and anti-symmetric wave functions, Bose particles or bosons, Fermi particles or fermions, Calculating the partition function for Bosons with a large number of levels, Calculating the partition function for Fermions with a large number of levels, Spin, Identical particles localized on lattice sites, Identical particles in a molecule, The probability that a particle is in a quantum state, Derivation of Maxwell-Boltzmann Distribution, Density of states in k space, Single-particle density of states in energy, The distribution of speeds of particles in a classical gas, Molecular beams. Black-body radiation, The Rayleigh-Jeans theory, Planck's distribution, Waves as particles, Derivation of the Planck distribution, The free energy, Einstein's model of vibrations in a solid, Debye's model of vibrations in a solid, Solid and vapor in equilibrium, Cosmic background radiation. Introduction, the statistical mechanics of identical particles, Fermi particle, Bose particle, the thermodynamic properties of a Fermi gas, High-temperature region, Properties at the absolute zero, Thermal properties of a Fermi gas at low temperatures, A non-interacting Bose gas. systems with variable number of particles, The condition for chemical equilibrium, The approach to chemical equilibrium, The

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chemical potential, Method of measuring μ, Methods of calculating μ, Reactions, External chemical potential, The grand canonical ensemble, Absorption of atoms on surface sites, The grand potential,

Text book Roger Bowley and Mariana Sanchez, "Introductory Statistical Mechanics", Clarendon Press Oxford, second edition 1999.

Reference Books

1. Harvey Gould and Jan Tobochnik, "Statistical and Thermal Physics with Computer Application", second edition 2010.
2. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Press Inc. 2008

PHYS-364 Mathematical Method for Physicists II Cr.Hrs: 3

Objectives This course provides an introduction to methods for solutions of the periodic/non periodic functions, integrals, differential equations in mathematical physics, series solution, etc. This may provide a base to advance theoretical physics.

Course Outline:

Periodic functions, Fourier coefficients, Dirichlet conditions, complex form of Fourier series, Fourier coefficients at other intervals, even and odd functions, application to sound, Parseval's theorem, Fourier transforms. separable equations, linear first-order equations, exact equations, homogenous equations, second-order linear equations with constant coefficients, Laplace transform, solutions of differential equations by Laplace transforms, introduction to green functions. gamma function; recursion relation, the gamma function of negative numbers, beta functions, beta functions in terms of gamma functions, the error function. Solution of differential equations using power series method, Legendre's equation, Leibniz rule, Rodrigues formula, generating function, Bessel's equation, second solution of Bessel's equation, Hermite functions; Laguerre functions; ladder operators. Laplace equation, heat flow equation; the Schrodinger equation, the wave equation, steady state temperature in a cylinder. Contravariant, covariant, and mixed tensors. Metric tensors.

Recommended Books:

1. Mary L. Boas Mathematical Methods In The Physical Sciences Third Edition.
2. Mathematical Methods for Physicists*:* by Arfken & Weber, publisher: Academic Press; 6th Edition, (2005)
3. Mathematical Methods for Physicists: by Tai L. Chow, publisher: Cambridge University Press, (2002)

PHYS-365 Quantum Mechanics I Cr. Hrs: 3

Course Objective: This course aims to provide an introduction to the basic ideas and the actual mechanics of quantum mechanics. Through lectures, discussions, and homework

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problems, students will be able to use quantum mechanics to solve a variety of interesting problems, as well develop some insight into what the solutions really mean.

Contents:

Historical motivation: wave-particle duality, photo-electric effect, instability of atoms, black body catastrophe.

The wave Function: Schrodinger Equation, The Statistical interpretation, probability, Normalization, Momentum, The uncertainty principle.

Time-Independent Schrodinger Equation: Stationary States, The infinite square well, The Harmonic oscillator, the free particle, the Delta-function potential, the finite square well.

Formalism: Hilbert space, Observables, Eigen functions of a Hermitian operator, generalized statistical interpretation, the uncertainty principle, Dirac notation.

Quantum Mechanics In Three Dimension: Schrodinger equation in spherical coordinates, the hydrogen atom, angular momentum, Spin.

Identical Particles: Two particle systems, atoms, solids, Quantum statistical mechanics.

Text Book: Introduction to Quantum Mechanics (Latest edition) by David J. Griffiths.

Recommended texts:

1. Introductory Quantum Mechanics, by Richard L. Liboff, publisher: Addison Wesley; 4th Edition, (2002).
2. Quantum Physics, by Stephen Gasiorowicz, publisher: John Wiley, 3rd Edition (2005).
3. Shankar, Ramamurti. Principles of Quantum Mechanics. Springer, 2008.
4. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë "Quantum Mechanics", Wiley; 1st edition (January 8, 1991).

PHYS-366L Lab- VI (Nuclear Physics)

Cr.Hrs: 2

Objectives:

This lab should help students to understand the role of direct observation in physics and to distinguish between inferences based on theory and the outcomes of experiments. Further to get familiar with the relationship between electrical, optical and magnetic devices. To expose the students to advance level experimentation in Nuclear Physics

1. Study of laser parameters. Gain characteristics and spectral response of a photo-multiplier tube.

2. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils.

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3. 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.
4. Measurement of the spectrum of gamma rays from a radioisotope. Shielding and attenuation of gamma rays.
5. To study the characteristics of a solid-state detector and use it to measure the spectra of alpha and beta particles.
6. Use of a Lithium-drifted Ge-counter for gamma spectroscopy and to compare its performance with that of a Nal-detector.
7. To study the characteristic curves of a G. M. counter and use it to determine the absorption co-efficient of β-particle in Aluminum.
8. Determination of range of α particles.
9. Mass absorption coefficient of lead for γ-rays using G.M counter.
10. Measurement of the total neutron cross-section.
11. Determination of the constituents of substance by activation analysis.
12. Measurement of the spectrum of gamma rays from a radioisotope
13. 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.
14. Nuclear magnetic resonance (N.M.R.) of protons in water.
15. 8. To examine the stopping-power of various substances for thermal neutrons.
16. 2. Understand the behavior of nuclear radiation including beta and gamma radiation.

Recommended Books:

1. H.Mark and H.T. Olsono. Experiments in Modern Physics (McGraw-Hill).
17. A.C. Melissinos. Experiments in Modern Physics (Academic).
18. G. L. Squires, Practical Physics, 3rd Edition, Cambridge University Press

4. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
5. C. K. Bhattacharya, University Practical Physics, CBS Publishing.

Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-e-Azam University Islamabad, Punjab University.(Ref. Lab-VI)

PHYS-471 Solid State Physics I Cr.Hrs: 3

Objectives:

Solid State Physics deals with the study of matter and provides theoretical basis to the Material Science. The course emphasizes on the correlation between crystal structure and physical properties such as (Mechanical, Electrical and Magnetic) as well as chemical properties (Bonding, Symmetries, Phase transition). The course is mathematically rich and experimental techniques employed to verify various phenomena are the essence of this subject.

Course Outline:

Types of lattices, Symmetries, Closed packed structures, Bragg's Law, Reciprocal Space, Brillouin Zones, Structure Factor, Atomic Form Factor, Cohesive energy, Bonding, lattice

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constant, Elastic waves, Dispersion relation of a monatomic lattice, Diatomic lattice, Quantization of elastic waves, Phonons momentum, Inelastic scattering by phonons, Phonon Heat capacity, Planck distribution, Normal mode enumeration, Einstein theory, Density of states in one and three dimensions, Debye theory, Anharmonic crystal interactions, Thermal expansion, Thermal conductivity, Thermal resistivity of Phonons gas, Umklapp processes, Imperfections.

Recommended Books:

C. Kittel, Introduction to Solid State Physics (8th Edition), John Wiley & Sons, Inc/2002
Ashcroft & Mermin, Solid State Physics (1st Edition), Harcourt College Publisherl1976

PHYS-472 Atomic and Molecular Physics **Cr. Hrs: 3**

Course Description:

This course is an introduction to atomic and molecular physics with nonrelativistic quantum mechanics and elementary mathematical physics as prerequisites. This course of lectures is designed to serve two main objectives to develop the students skills to solve real physical problems using quantum mechanical formalism.

Course Outlines:

Electron photon and atom: History and structure of atoms The electron, Black body radiation, Photoelectric effect, Compton effect, Atomic Spectra, Spectrum of H-atom, Review of Bohr's theory of H-atom, Stren-Gerlach experiment, Angular momentum and Spin, De-Broglie's hypothesis Problems discussion. The elements of quantum Mechanics: Waves and particles, wave packets, Uncertainty principle, Schrodinger equation, Expansions, operators and observable, One dimensional example, Angular momentum, Central forces, Several-particle system, Approximation methods,. One electron atoms: Schrodinger equation for one electron system, energy level, eigen function of bound states, Expectation values, Virial theorem Special Hydrogenic systems. Interaction one one electron systems with electromagnetic radiations: Electromagnetic field and its interaction with charged particles, Transition rates, Dipole approximation, Einstein Coefficient, Selection rules and the spectrum of one electron atoms, Line intensities, Excited states, life time of excited states, Line shapes and widths, One electron atoms fine structure, Hyperfine structure and interaction with external electric and magnetic fields, Fine structure, Zeeman effect, Stark effect, Lamb Shift Hyperfine structure.

Recommended Books

1. B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules, 2nd Edition, Pearson Education, (2003)
2. Anne P. Thorn, Spectrophysics, 2nd Edition, Chapman and Hall, 1988

PHYS-473 Nuclear Physics **Cr.Hrs: 3**

Course Objectives:

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To acquire an understanding of nuclear structure, basic nuclear properties and to study the different nuclear models. To study radioactivity and the various types of radioactive decay. To study nuclear reactions and different types of nuclear reactions

Course Contents:

Basic Concepts of Nuclear Physics: Introduction to Nuclear Physics, Basic Properties of the Nucleus (such as Mass Number, Nuclear Mass and Nuclear Radius), Isotopes, Rutherford Scattering and Estimation of Nuclear Size, Experimental Measurement of Nuclear Radius, Constituents of the Nucleus and their Properties, Nuclear Binding Energy, The Semi-Empirical Mass Formula, Nuclear Magnetic Moments, Parity of Nuclear Levels, The Nuclear Force (Basic Idea), Nuclear Models

Radioactivity: Historical Background of Radioactivity, The Radioactive Decay Law, Half-life and Mean Lifetime, Production and Decay of Radioactivity, Radionuclides with More Than One Mode of Decay, Chain Disintegrations, Ideal Equilibrium, Secular Equilibrium, Transient Equilibrium, Alpha Decay, The Alpha Decay Paradox, Theory of Alpha Decay, Range of Alpha Particles in Matter, Beta Decay, Continuous Energy Spectrum of Beta Particles, Positive Beta Decay, Negative Beta Decay, Electron Capture, The Neutrino Hypothesis, Detection of Neutrino, Fermi's Theory of Beta Decay, Gamma Decay, Selection Rules for Gamma Emission, Internal Conversion, Internal Pair Production, Nuclear Isomerism, Parity and Electric and Magnetic Multipoles, Electric and Magnetic Multipole Radiations

Nuclear Reactions: Basic Nuclear Reactions, Types of Nuclear Reactions, The Balance of Mass and Energy in Nuclear Reactions, The Q-value Equation, Exothermic and Endothermic Nuclear Reactions, Threshold Energy, Nuclear Fission, Theory of Nuclear Fission, Spontaneous Fission, Fission with Liquid Drop Model, Nuclear Fusion, Controlled Thermonuclear Fusion

Recommended Books:

1. E. Segre, Nuclei and Particles, Benjamin, 1977.
2. S. B. Patel, Nuclear Physics: An Introduction, Wiley Eastern Limited
3. Kaplan, Nuclear Physics, Addison-Wisely, 1980.
4. Kenneth S. Krane, Introductory Nuclear Physics, 1995.
5. B. Povh, K. Rith, C. Scholtz, F. Zetsche, Particles and Nuclei, 1999.

PHYS-474 Introductory Quantum Mechanics II Cr.Hrs: 3

Course Objective: This course aims at the applications of quantum mechanics, approximation schemes and deeper understanding of some philosophical questions in quantum mechanics.

Contents:

Time Independent Perturbation Theory: Nondegenerate perturbation theory, degenerate perturbation theory, the fine structure of Hydrogen, The Zeeman effect, Hyperfine splitting. The Variational Principle: Theory, the ground state of Helium, The Hydrogen molecule ion. The WKB Approximation: The Classical region, tunneling, the connection

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formulas. Time Dependent Perturbation Theory: Two level systems, emission and absorption of radiation, spontaneous emission. The Adiabatic Approximation: The adiabatic theorem, Berry's Phase. Scattering: Introduction, Partial wave analysis, phase shifts, The Born approximation. EPR paradox, Bell's theorem, Schrodinger's cat, No-clone theorem, Quantum Zeno paradox.

Text Book: Introduction to Quantum Mechanics (Latest edition) by David J. Griffiths.

Recommended texts:

1. Introductory Quantum Mechanics, by Richard L. Liboff, publisher: Addison Wesley; 4th Edition, (2002).
2. Quantum Physics, by Stephen Gasiorowicz, publisher: John Wiley, 3rd Edition (2005).
3. Shankar, Ramamurti. *Principles of Quantum Mechanics*. Springer, 2008.
4. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë "Quantum Mechanics", Wiley; 1st edition (January 8, 1991).

PHYS-475L Lab-VII (Solid State Physics) Cr.Hrs: 3

Objectives: The laboratory should help students master in basic physics concepts. The aim of this lab is to give students with the practical understanding of detectors, accelerators, and interferometer and most importantly about the nuclear phenomenon and their uses in real world.

1. Experiments with microwaves. Study of their optical properties.
2. Electron spins resonance (E.S.R.) by microwave absorption.
3. The study of the Mossbauer effects.
4. The measurement of the Hall effects in germanium and silicon.
5. Measurement of the conductivity of Si and Ge as functions of temperature.
6. To determine the energy gap in silicon and Germanium.
7. Drift mobility. (Shockley-Haynes experiments for Germanium, demonstrating transistor action).
8. To study the B.H. curve & measure the magnetic parameters.

Books Recommended:

1. H.Mark and N.T. Olson, Experiments in Modern Physics (McGraw-Hill).
2. A.C. Melissionos, Experiments in Modern Physics (Academic).

Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-e-Azam University Islamabad, Punjab University.

PHYS-481 Solid State Physics II Cr.Hrs: 3

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Objectives:

Solid State Physics is considered a laboratory for Quantum Mechanics. The Quantum theory is used as a tool to understand, predict and optimize the properties of materials. The course as it stands could serve as a basic outline for applications of quantum theory to solids.

Course Outline:

Energy levels in one dimension, Fermi-Dirac distribution, Free electron gas in one and three dimensions, Fermi surface and density of states, Heat Capacity of Electron gas, Electrical conductivity and Ohm's law, Matthiessen's rule, Umklapp scattering, Hall's effect, Wiedemann-Franz law, Nearly free electron model, Origin of bands, Bloch functions, Kronig-Penny model, crystal momentum of electron, Solution of the central equation, Empty lattice approximation, Band gap, Holes and effective mass, Effective masses in semiconductors, Intrinsic and extrinsic carrier concentrations, Thermal ionization of donors and acceptors, Thermoelectric effects, Semimetals, Superlattices, Zener tunneling, Langevin diamagnetism equation, Paramagnetism, Crystal field splitting, Spectroscopic splitting factor, Nuclear demagnetization, Maxwell's equations, Macroscopic electric field, Lorentz field, Dielectric constant and polarizability, Structural phase transition, Ferroelectric crystals, Landau theory, Piezoelectriccity, Crystal defects, Diffusion, Color centers.

Recommended Books:

1. C. Kittel, Introduction to Solid State Physics (8th Edition), John Wiley & Sons, Inc/2002
2. Ashcroft & Mermin, Solid State Physics (1st Edition), Harcourt College Publisherl1976

Study tour: A study tour may be arranged for students to various Physics research institutes/centers, such as National center for Physics (NCP), National institute of Lasers and Optronics (NILOP), Quaid-IAzam University Islamabad, Punjab University.

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DETAILS OF ELECTIVE COURSES FOR BS (4-Year) PROGRAM

These elective courses can be chosen from the list or new elective course may be offered according to the availability of staff and necessary infrastructure. University may also tailor these courses according to their facilities.

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PHYS-482 Particle Physics **Cr.Hrs: 3**

Outlines:

Particle Classification: Quantum numbers, leptons, hadrons, baryons, mesons, quarks.

The Fundamental Interactions: The electromagnetic coupling, the strong coupling, the weak coupling.

Symmetry Transformation and Conservation Laws: Translation in space, rotation in space, the group SU (2), systems of identical particles, parity, iso-spin charge conjugation, time reversal, G parity, CPT theorem.

The Electromagnetic Field: Gauge invariance and Maxwell's equations, polarization ad photon spin, angular momentum, parity and C parity of photon.

Hadron Spectroscopy: Formation experiment, partial wave formalism and the optical theorem, the Breit-Wigner resonance formula, baryon resonances, phase space considerations, production experiments.

The Quark Model: The group SU (3), quarks, hadrons baryons, mesons in quark model, heave meson spectroscopy, the quarkonium model.

The Standard Model (qualitative treatment only):

Unification of weak and electromagnetic interactions Glashow-Salam-Weinberg Model.

Books Recommended:

1. Relatvistic Quantum Mechanics by Bjorken, J. D. and Drell, S.D., McGraw Hill,(1995).
2. Quarks and Leptons by Halzen, F. and Martin, A.D., John-Wiley and Sons. (1984).
3. Quantum Mechanics by Riazuddin and Fayyazuddin, World Scientific, (1990).
4. Introduction to Elementary Particles by Griffiths, D., John-Wiley and Sons, (1987).

PHYS-483 Plasma Physics **Cr.Hrs: 3**

Introduction, Occurrance of plasma. Concept of temperature. Debye shielding. The plasma parameter. Criteria for plasma. Applications of plasma physics. Single-particle motion in electromegnatic field. Uniform and nonuniform E and B fields. Time-variant E and B fields. Fluid description of plasma. Wave propagation in plasma. Derivation of dispersion relations for simple electrostatic and electromagnetic modes. Introduction to Controlled Fusion: Basic nuclear fusion reactions. Reaction rates and power density, radiation losses from plasma, operational conditions.

Books Recommended:

1. F.F.Chen, Introduction to plasma Physics, 2nd ed. (Plenum).
2. N.A.Krall and A.W.Trivelpiece, Principles of Plasma Physics, 1973 (McGraw Hill).
3. S.Glasstone and R.H.Lovberg, Controlled Thermonuclear Reactions, 1960 (D.Van Nestrand).

PHYS-484 Surface Physics **Cr. Hrs: 3**

Objectives:

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Surface Physics is an emerging science because of the peculiar behavior of constituent particles on the top outermost layers of solid. The course is intended to acquire skills needed to deposit layers on the surface of a substrate to achieve optimized properties.

Course Outline:

Definition of surface, Vacuum, Ultra high vacuum, Substrate, Surface diffusion, Reconstruction of surfaces, Superstructure, Kinetic theory of gases, Adsorbate structure, Mesh, Spintronics, Surface epitaxy, Electron tunneling, Nanostructures, High energy electron diffraction, Work function, Thermionic emission, Surface states, Tangential surface transport, Magneto resistance in a two dimensional channel, Integral quantized Hall effect, Diodes and p-n junctions, Hetrostructures, Solar cells and photovoltaic detectors, n-N Hetrojunction, Semiconductor lasers, Light emitting diodes, Surface X-ray scattering, Raman spectroscopy, X-ray photoelectron spectroscopy,

Recommended Books:

1. Prutton, Martin, Introduction to Surface Physics.(1st Edition) Oxford University Press,1994.
2. A.J. Venables, Introduction to Surface Physics.(1st Edition) Cambridge University Press.

PHYS-485 Fluid Dynamics **Cr. Hrs: 3**

Course Description:

This course provides an introduction to principal concepts and methods of fluid mechanics. Topics covered in the course for understanding basic laws, principles and phenomena in the area of fluid mechanics, analyze, and design fluid systems through the applications.

Course Outlines:

Basic concepts of fluid mechanics: Fundamental terms, Physical values, Fluids and their properties, Forces inside fluid, Pascal's law. Euler's equation of fluid statics, Measurement of pressure, Relative statics of fluid: constant acceleration, rotation, Forces of hydrostatic pressure, Buoyancy, Flotation, Stability, Euler and Lagrangian specification of fluid flow, Streamlines, Pathlines, Stream surface, Stream tube, Mass/volume flow, Control volume, Continuity equation, Basic laws of fluid dynamics: conservation of mass, linear momentum, and energy, Ideal fluid flow. Application of Bernoulli's equation: Real fluid flow, Viscosity, Determination of losses, Reynolds experiment, Laminar and turbulent flow, Boundary layer, Velocity profile, Losses in pipes, Frictional losses, Nikuradse experiments, Moody's diagram, Local losses, Coefficients of resistance.

Recommended Books

1. Joseph H. Spurk · Nuri Aksel, Fluid Mechanics, 2nd Edition, 1997 Springer-Verlag Berlin Heidelberg
2. Y. Nakayama and R. F. Boucher, Introduction to Fluid Mechanics 1999, Oxford Auckland Boston Johannesburg

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3. B. N. Hewakandamby A First Course in Fluid Mechanics for Engineers, ISBN: 978-87-4030069-7.

PHYS-486 Methods of Experimental Physics **Cr. Hrs: 3**

Course Objectives:

Experimental techniques are used to verify a model or a phenomenon. A phenomenon is true only when it is consistent with the experiment otherwise it is wrong. This course intends to develop skills needed for carrying out the experiments and data analysis to check whether the theory/phenomenon is in agreement or not.

Course Outlines:

Vacuum Techniques: Gas Transport: Throughout, Pumping Speed, Pump down Time Ultimate pressure. Fore-Vacuum Pumps: Rotary Oil pumps; sorption pumps. Diffusion pumps, sorption pumps (High Vacuum). 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, Perini gauges The McLoad 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 feed throughs & Electrical feed throughs Leak detection: Basic consideration, leak detection equipment, Special Techniques and problems, Repair Techniques,

Radiation Detection and Measurement: GM tubes, scintillation detector, channeltron, photo multipliers, neutron detectors, alpha/beta detectors, x-rays/gamma detectors, cosmic rays detectors, Spectrographs and Interferometers.

Books Recommended:

1. H.D.Young, Statistical Treatment of Methods of Experimental Physics, Academic Press, Inc. New York & London Vol.1.
2. J. Yarwood, High Vacuum Techniques, Chapman Hall.
3. P. Bevington, Data Reduction and Error Analysis for Physical Science, McGraw Hill.

PHYS-487 Environmental Physics **Cr.Hrs: 3**

Environmental Physics serves as an introduction to physics in the context of societal problems such as energy supply, pollution, climate change and finite resources of fossil fuels and uranium. The course emphasis the concepts and principles that help in understanding the ways to produce energy efficiently or to mitigate climate change. It text explains the physical mechanisms behind climate change and discusses the physics of renewable energy options.Physics can never be taken in isolation when dealing with environmental problems. It does however play a pivotal role in exploring, monitoring and

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above all understanding the world we live in, and our effects on it, both on local and a global scale

Course Out line:

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 unduling areas, Dynamic action of seliq. Thermal action of selief, Climatology and Measurements of Climate Factor, Data collection and organization, statistical analysis of climatic data, climatic indices, General characteristics of measuring equipments. Measurement of temperature, air humidity, surface wind velocity, Radiation balance, precipitation, Atmospheric Pressure, automatic weather stations.

Books Recommended:

1. Egbert Booker and Rienk Van Gron Belle, Environmental Physics, 2nd ed. John Wiley
   and sons. 1999.
2. Physics of Environmental and Climate, Guyot Praxis Publication. 1998

PHYS-488 Quantum Information and Quantum Computation Cr.Hrs: 3

Course Objective: The aim of this course is to understand basic concepts and skills that are essential for quantum information and computation.

Contents:

Computer technology and historical background, Basic principles and postulates of quantum mechanics, Qubits and Quantum states, Matrices and operators, tensor product, quantum measurement, superposition, quantization from bits to qubits, operator function, The density operators, Schrodinger equation, Schmidt decomposition, EPR and Bell's inequality, Quantum Computation, Quantum Measurement theory, Quantum entanglement theory, entanglement teleportation, Quantum gates and Circuits, Controlled operations, Quantum Cryptography, RSA cryptography, Code breaking on classical and quantum

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computers, Uncertainty principle, Polarization and Spin basis, BB84, BB90, and Ekert protocols, Experimental realization, Quantum Search Algorithm, Quantum Noise and error correction, Tools of Quantum information theory.

Books Recommended:

1. Quantum Computation and Quantum Information by M. A. Nielson and I. L. Chuang, Cambridge University Press, Cambridge 2000.
2. Quantum Computing latest edition by David McMahon.
3. Quantum Computation by P. Bouwmester, A. Ekert, and A. Zeilinger, Springer Verlag, Berlin, Heidelberg (2000).
4 Mathematics of Quantum Computation by A.K.Brylinsky and G. Chen, Chapman & Hall/CRC (2002).
5 Principle of Quantum Computation and information latest edition by Giuliano Benenti, Giulio Casati, Giuliano Strini, Volume-1 and volume-2.

PHYS-489 Semiconductor Physics **Cr. Hrs: 3**

Course Description:

This course is designed to be a deep dive into the fundamentals of the semiconductor devices that form the backbone of our current integrated circuits technology. Students will gain valuable experience in semiconductor physics and in semiconductor devices in the modern developments.

Course Outlines

General materials properties, Crystal structure, The unit cell concept, simple 3D, unit cell, Bravais lattice and Crystal system, Specific Semiconductor Lattice, Miller indices,The Quantum concept, Basic formalism (General formulation, Time independent formulation), Preliminary Considerations (Simplifying Assumptions, The Bloch Theorem), Approximate One-Dimensional Analysis (Kronig-Penney Model), Mathematical, Energy Bands and Brillouin Zones, Particle Motion and Effective Mass, Carriers and Current, Extrapolation of Concepts to Three Dimensions (Brillouin Zones), *E-k* Diagrams, Constant-Energy Surfaces,Effective Mass **,** General Considerations, Ge, Si, and GaAs, Measurement, Band Gap Energy,Density of States(General Derivation), Specific Materials(Conduction Band-GaAs, Si, Ge),Valence Band-Ge, Si, GaAs, Fermi Function**(**Introduction, Derivation Proper, concluding discussion), Supplemental Information(Equilibrium Distribution of Carriers, The Energy Band Diagram), Donors, Acceptors, Band Gap Centers Equilibrium Concentration Relationships(Formulas for n and p, ni and the np Product, Charge Neutrality Relationship, Relationships for N_D and $N_{A,}$), Concentration and EF, Calculations (General Information, Equilibrium Carrier Concentrations Freeze-Out/Extrinsic T and Extrinsic/Intrinsic T), Determination of E_F Exact Position of Ei, Degenerate Semiconductor Considerations

Recommended Books:

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1. Robert F. Pierret Purdue University, Advanced Semiconductor Fundamentals, volume VI, 2nd Edition, Pearson Education.
2. Ben G. Streetman, Solid State Electronic Devices, 7th Edition, 1972.
3. Donald A. NeamenUniversity of New Mexico, Semiconductor Physics and Devices, 3rd Edition, McGraw Hill Higher Education (2003)
4. S.O. Kasap, Principles of electronic materials and devices, 2nd Edition, McGraw Hill Higher Education.

PHYS-490 Computer Simulations Cr.Hrs: 3

Objectives: Computer simulation is the reproduction of the behavior of a system using a computer to simulate the outcomes of a mathematical model associated with the said system. Computer simulation allow us to check the reliability of chosen mathematical models. It can be used to explore and gain new insights into new technology and to estimate the performance. The course provide the basic concepts and skills for graphical and mathematical manipulation of the data for research students.

Course Out line:

Introduction, Mathematica, Matlab and Minitab'sprogramming mechanisms, Computer graphics and programming languages, 2D and 3D Plotting and designing, Solving a system of equations, Numerical Solution of Polynomial Equations, Numerical Solution of Differential Equations, To find roots of polynomial equations, solving square roots, Constructing Matrices, Matrix Operations, Advanced Matrix Operations, MatrixPlotting, Integration, Numerical Sums and Products, Advanced Numerical Integration, Numerical Calculations, Computer programming, Solution of Ordinary Differential Equations, initial (boundary) and Eigen value problems, numerical integrations, special functions and Gaussian, partial differential equations, Mean values and Expectation values, Probability calculation and plotting and Variance , Tools of CorelDraw, Tools of Latex.

Books Recommended:

1 . The Mathematica, latest edition by Stephen wolfram.
2. The CRC Encyclopedia of Mathematics, Third edition-3Volume set 3rd Edition by Eric Weistein.
3. Discrete mathematics through the use of Vilcretas package, by Enrique vilchez Q.
4. A practicle application to programming and Problem solving, latest edition, by stormy Attaway.

PHYS-491 Digital Electronics Cr.Hrs: 3

Objectives: This subject covers the basics of digital logic circuits and design. Through the basic understanding of Boolean Algebra and Number systems, it introduces the student to

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the fundamentals of combination logic design and then to sequential circuits (both synchronous and asynchronous).Memory systems are also covered.

Course Outline:

Number Systems, operations and codes. Digital Electronic. Signals and Switching devices, Logic Gates, AND, OR, NOT, NAND, NOR, XOR, XNOR. Boolean Algebra and Logic Simplification, Modular implementation of combinational logic circuits. Karnaugh maps & truth tables. Different logic families: TTL, Emitter Coupled Logic, NMOS, Combinational logic circuits: adders, subtractors, comparator, encoder, decoder, multiplexer, de-multiplexer, A/D and D/A converter. Components of sequential circuits: Flip flops, their characteristics and transition tables for sequential circuit Number Systems, operations and codes. Digital Electronic Signals and Switching devices, Logic Gates, AND, OR, NOT, NAND, NOR, XOR, XNOR.

Boolean Algebra and Logic Simplification, Modular implementation of combinational logic circuits. Karnaugh maps & truth tables.

Different logic families: TTL, Emitter Coupled Logic, NMOS, CMOS.

Combinational logic circuits: adders, subtractors, comparator, encoder, decoder, multiplexer, de-multiplexer, A/D and D/A converter.

Components of sequential circuits: Flip flops,

their characteristics and transition tables for sequential circuit design, registers, counters, Multi-vibrators, Memories.

Recommended Books:

1. Thomas L. Floyd, Digital Fundamentals, 11th edition, 2015, Pearson.
2. M. Morris Mano, Digital Circuits and Computer Logic, 2nd edition, 2006, Pearson.
3. William Kleitz, Digital Electronics A Practical Approach with VHDL, 9th edition, 2011, Pearson.
4. Digital Computer Electronics by Albert P. Malvino, Jerald A. Brown, 3rd edition, 1993, McGraw-Hill.

PHYS-492 Experimental Nuclear Physics Cr.Hrs: 3

Nuclear Radiation Detection and Measurements: Interaction of nuclear radiation with matter; photographic emulsions; Gas-filled detectors; Scintillation counters and solid-state detectors; Cloud chambers; Bubble chambers. Charged Particle Accelerators: Linear and orbital accelerators, Van de Graaff, Cyclotron; Betatron; Synchrocyclotron; Electron-Synchrotrons; Proton-synchrotron; Alternating-gradient Synchrotron.

Neutron Physics: Neutron Sources, Radioactive sources, Photo neutron sources, Charged particle sources, Reactor as a neutron source, slow neutron detectors, fast neutron detectors, Measurement of neutron cross-sections as a function of energy, slowing down of neutrons, Nuclear fission, Description of fission reaction, Mass distribution of fission energy. Average number of neutrons released, Theory of fission and spontaneous fission, Nuclear chain reaction and applications.

Elementary Reactor Physics: Controlled fission reactions, Types of nuclear reactors (Power and Research), Detailed study of PWR and CANDU type reactors.

Recommended Books:

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1. Glenn, F. Knoll, Radiation Detection and Measurement, John Wiley, 1989.
2. William, R. Leo, Techniques for Nuclear and Particle Physics, Springer, 1994.
3. Philips Berington and D. Keith, Data Detection and Error analysis for physical sciences, 2002.
4. E. Segre, Nuclei and Particles, Benjamin, 1977.
5. Kenneth S. Krane, Introductory Nuclear Physics, 1995.

PHYS-493 Laser Physics **Cr.Hrs: 3**

Course Objective: 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.

Contents:

Introductory Concepts: Spontaneous Emission, Absorption, Stimulated Emission, Unique Properties of Laser Light, Monochromaticity, Coherence, Directionality, and Brightness
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, Einstein's A & B Coefficients, 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, Matrix Formulation of Geometrical Optics, Stability Condition, Standing and Traveling Waves in a two Mirror Resonator, Three- and Four-Level Laser Systems, Optical pumping, Flash lamp and Laser, Continuous Wave (CW) and Pulsed Lasers, Rate Equations, Q-Switching and Mode-Locking Methods, Phase Velocity, Group Velocity and Group-Delay Dispersion, Laser Types and Laser 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).

PHYS-494 Fundamentals of Optoelectronics **Cr.Hrs. 03**

Prerequisites**:** Waves and optics, Modern physics, Quantum Physics

Course Objectives:

To study the application of light, studying the photonic devices including detectors.

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Course Contents:

Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides, Single and multimode 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, amplitude and phase 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, photo detector noise.

Recommended Books

1. Fundamentals of Photonics by B. E. A. Saleh and M. C. Teich (2nd Edition), John Wiley (2007).
2. Photonic Devices by J-M. Liu, Cambridge (2009).
3. Photonics: Optical Electronics in Modern Communications by A. Yariv and P. Yeh, Oxford (2006).
4. Optics by E. Hecht (4thEdition), Addison-Wesley (2001)

PHYS-495 Introduction to Materials Science Cr.Hrs:3

Pre-requisites: Solid State Physics-I

Course Objectives:

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.

Course Outlines:

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

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deformation; Slip systems; Dislocations and strengthening mechanisms; Fracture mechanics; Ductile and brittle fractures.

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).

PHYS-496 Introduction to Nano Science **Cr.Hrs:3**

Pre-requisite: Solid State Physics, Quantum Mechanics

Course Objectives:

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 Outlines

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;

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;

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.
5. Y.Gogotsi (Editor), Nano-Materials Hand Book, CRC Press, Taylor & Francis Group, (2006).

PHYS-497 Quantum Optics **Cr. Hrs: 3**

Pre-requisites: Electromagnetic Theory-I , Quantum Mechanics

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.

Contents:

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, quantum erasers, laser cooling and trapping of atoms.

Recommended Books:

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

PHYS-499 Internship **Cr.Hrs. 3**

PHYS-500 Undergraduate Project **Cr.Hrs. 3**

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

Department of Physics Chairman University of Malakand

Assistant Registrar (Academics) University of Malakand 05-Dec-2023