MS Weekend Program
Course Handbook

Syllabus for the Masters in Applied Physics and Electronics (Under Weekend Program)

(For students admitted in session: 2018-2019 to 2021-2022)

Department of Physics, Jahangirnagar University, Savar, Dhaka -1342, Bangladesh.

APE-5001: MECHANICS AND ELECTROMAGNETICS

1. **Vector :** Vector and scalar quantities; Vector addition and subtractions; Gradient of scalar quantities; Divergence and curl of vector quantities; Scalar and vector products and their significance; Line, surface and volume elements; Gauss's divergence theorem, Stokes' theorem and Green's theorem; Polar, spherical and cylindrical coordinates.
2. **Kinematics and Particle Dynamics:** Concept of motion and frames of reference; Equations of motion; Projectile motion; Uniform circular motion; Newton's laws of motion; Frictional forces. Work done by constant and variable forces; Kinetic and potential energies; Work-energy theorem; Conservative and non-conservative forces; Principle of conservation of energy. Centre of mass; Motion of a system of particles and its linear momentum; Conservation of linear momentum for a system of particles; Application of the linear momentum in the case of rocket propulsion; Collision phenomena.
3. **Properties of Matter:** Kepler's laws; Newton's law of gravitation; Mass and density of the earth; Gravitational field; Gravitational potential energy; Escape velocity; Energy and orbits; The acceleration due to gravity; Variations in 'g'; Stress; Strain; Hooke's law; Stress-strain diagram; Elastic hysteresis; Elastic modulii; Internal elastic potential energy; Hydrostatic pressure; Pascal's law; Center of pressure; Equilibrium of floating bodies; Pressure gauges. Surface tension; Surface energy; angle of contact and capillarity; Measurement of the angle of contact; Lines and tubes of flow; Equation of continuity; Viscosity; Coefficient of viscosity: Poiseuille's law; Stokes' law;
4. **Oscillations:** Simple harmonic motion (SHM); Applications of SHM; Relation between SHM and uniform circular motion; Equation of traveling waves; Longitudinal waves ; The superposition principle; Fourier series; Group speed and phase speed. Normal modes and proper frequencies of a stretched string. Intensity and intensity levels; Loudness and pitch; Waves in three dimensions; Interference of spherical (sound) waves; Diffraction of sound waves; Radiation efficiency of a sound source; Beats; Combination of tones; Doppler effect and its applications.

5. **Electricity** : Electric charge; Coulomb's law; Electric field; Point charge in an electric field; Dipole in an electric field; Electric flux; Gauss's law and some of its applications. Potential and field strength; Potential due to a point charge, A group of point charges and a dipole; Electric potential energy; Calculation of field strength from potential; Insulated conductor; Electrostatic generator.

6. **Capacitors and Dielectrics:** Capacitor and capacitance –its calculations for different geometry; Dielectric and Gauss's law; Parallel plate capacitor with and without dielectric; Three Electric vectors; Energy stored in an electric field.Current and current density; Drift speed of charge carrier; Resistance, resistivity and conductivity; Ohm's law; Resistivity: Atomic view; Energy transfer in an electric circuit., Electromotive force and potential difference; Kirchhoff's laws: Single loop and multi loop circuits; Potentiometer, ammeter, voltmeter and galvanometer; RC circuits.
7. **Magnetism:** Magnetic induction and magnetic effects of currents; Magnetizing force; Magnetic force on a charge and on a current; Torque on a current loop; Moving coil galvanometer; The Hall effect; Ampere's law and its applications; Magnetic effects of currents; Biot-Savart law and its applications. Faradays' law of electromagnetic induction; Lenz's law; Self and mutual inductance and their applications; LR circuit; Energy stored in a magnetic field.

BOOK RECOMMENDED

1. Spiegel, M.; Vector Analysis; McGraw Hill Book Company.
2. Resnick, R., Halliday, D. & K. Krane; Physics; John Wiley & Sons.
3. Sears F.W.; Mechanics, Wave Motion and Heat; Addison Wesley Publishing Company.
4. Resnick, R. and Halliday, D. and Walker, J.; Fundamental of Physics; John Wiley and Sons.
   Halliday, D.; & Resnick, R; Physics; New Age International Publishers; Revised Edition 2002.
5. Huq., M.S.; Rafiqullah, A.K., & Roy, A.K; Concepts of Electricity and Magnetism; Students Publications; 3rd Edition.

APE- 5002: QUANTUM PHYSICS

1. **Physical Basis**: Failures of classical mechanics and emergence of quantum mechanics; Bohr atom and old quantum theory; Domain of quantum mechanics; Heisenberg uncertainty principle.

2. **Formulation**: Concepts and postulates of quantum mechanics; Operators and commutation of operators; State function and state function space; Hilbert space; Eigenvalue equations; Eigenfunctions and basis vectors; Hermitian operators; Dirac's Bra and Ket notations; Measurements in quantum mechanics: Expectation values; Orthogonality and the sharing of eigenfunction sets.

3. **Schrödinger's Equation**: Hamiltonian operator; Time-dependent and time-independent Schrödinger's equations; Time variation of expectation values; Probability current density; Ehrenfest's theorems.

4. **Harmonic Oscillator**: Potential step; Potential barrier; Potential well; Quantum mechanical tunneling; Solution of Schrödinger's equation for the one-dimensional harmonic oscillator; Eigenenergies and eigenfunctions of harmonic oscillator; Expectation values of some observables for the pure and mixed states of harmonic oscillator.

5. **Hydrogen atom :** Schrödinger's equation for the hydrogen atom in spherical coordinates; Angular momentum; Operators in Cartesian coordinates; Commutation relations; Angular momentum operators in spherical polar coordinates; Solution of the angular and radial part of the Schrödinger's equation of the hydrogen atom.

BOOK RECOMMENDED

1. Goldstein, H.; Classical Mechanics; Addison-Wesley/Narosa Publishing House.
2. Gupta, Kumar and Sharma; Classical Mechanics; Pragati Prakashan.
1. White, R. L.; Basic Quantum Mechanics; McGraw Hill Company Limited.
2. Eisberg, R. M.; Fundamentals of Modern Physics.
3. Feynman, R. P., Leighton, R.B. and Sands, M.; The Feynman Lectures in Physics; Narosa Publishing House.

APE-5003: OPTICS & ELECTRONICS
Part-A

1. Semiconductors; Semiconductor diode, Rectifier and Filter Circuits: Energy Band Description of semiconductors; Effect of temperature on semiconductors; Intrinsic semiconductor; Extrinsic semiconductors; P-type semiconductors; N-Type semiconductor; Properties of PN junction; Half-wave rectifier; Full-wave rectifier; Filter circuits; Ripple Factor Capacitor filter; Zener diode; Voltage stabilization.

2. Transistor Devices and Circuits: Transistors and its action; Transistors connections; Common base, common emitter, common collector connections, and their characteristics; Transistor load line analysis; Transistor biasing; Methods of transistor biasing: base resistor method, biasing with feedback resistor, voltage divider biasing method.

3. Transistor Amplifier: Classifications of amplifiers: Single stage and multi-stage transistor amplifiers; R-C coupled and transformer coupled transistor amplifiers; Power amplifier: Class A, class B, and class C amplifiers; Push-pull amplifier.

4. Basic Operational Amplifier: Ideal Op-amp; Inverting and non-inverting Op-amp; Adder and subtractor; Integrator; Differentiator.

Part-B

5. **Interference:** Condition of interference, Young's experiments; Analytical treatment of interference, Fringe width, Newton's ring experiment, determination of unknown wavelength.

6. **Diffraction:** Diffraction phenomena; Types of diffraction; Diffraction by a single slit; Diffraction by a double slit; Plane diffraction grating; Dispersive power and resolving power of a grating.

7. **Polarization:** Polarization of light; Polarization by reflection; Brewster's law; Double refraction; circular Polarization; Nicol Prism; Optical activity; Specific rotation.

8. **Optical instruments:** Telescope; Microscope; Spectrometer; Polarimeter.

BOOK RECOMMENDED:

1. Robert L. Boyelstad, Louis Nashelsky Electronic Devices and Circuit Theory.
2. Mehta, V. K.Principles of Electronics
3. Theraja, B. L Basic Electronics Solid Stat
4. Jenkins, F. A. and White, H.E. Physics
5. Halliday, D. and Resnick, R Physics
6. Morgan J.Introduction to Geometrical & Physics Optics.
7. Bom, M. and Wolf, B. Principles of Optics

APE- 5004: ATOMIC & NUCLEAR PHYSICS

1. Particle Properties of Waves: Particles and waves in nature; Electromagnetic radiation; Photoelectric effect and its important features; Compton effect; Pair production and pair annihilation; Concept of light; Photons and gravity; Black holes; X-rays: Production of continuous and characteristic X-rays; X-ray diffraction.

2. Wave Properties of Particles: de Broglie's hypothesis; Phase velocity and group velocities of matter waves; Particle diffraction; Davission-Germer experiment; Uncertainty principle and its applications.

3. Atomic Structure: Thomson model of atom; Alpha-particle scattering experiment and Rutherford model; Nuclear dimensions, Electron orbit; Atomic spectra-the Bohr atom, Energy levels and spectra; Atomic excitation-Frank-Hertz experiment; Nuclear motion and reduced mass.

4. Quantum Concepts and Detailed Atomic Structure: Schrodinger equation; Four quantum numbers; Normal Zeeman effect; Stern-Gerlach experiment; Electron Spin, Fine structure and anomalous Zeeman effect; Pauli exclusion principle and the periodic table; Vector atom model *l-s* and *j-j* coupling; Many-electron atoms and atomic spectra.

Part-B

5. Nuclear Properties: Constitution of the nucleus; Nuclear mass; Nuclear radius; Mirror nuclei; Coulomb displacement energy; Mass defect; Binding energy: Binding energy curve; Semi-empirical mass formula; Angular momentum: Spin, parity and symmetry; Magnetic dipole moment and electric moments; Mirror

Nuclei; Coulomb energy.

6. Radioactivity: Stable and unstable nuclei; Natural and artificial radioactivity; Radioactive decay law; Successive radioactive transformations; Radioactive equilibrium; Radiometric dating, Types of decay.

7. Different Decay Processes: Alpha Decay: Alpha decay properties; Condition of alpha decay. Fine structure; Measurement of alpha-particle energies. **Beta Decay:** Introduction; Conservation of energy; Conservation of angular momentum; **Gamma Decay:** Properties of gamma rays.

8. Nuclear Reactions: Nuclear and chemical reactions, The Q-value equation and threshold energy; Neutron and neutron flux; Fission and fusion reactions; Fission energy and thermonuclear energy.

BOOK RECOMMENDED:

1. Beiser, A.; Concepts of Modern Physics; McGraw-Hill International.

APE 5005: POWER ELECTRONICS AND CONTROL SYSTEM

1. **Power Semiconductor Diode, Reverse Recovery Characteristics:** Power diode types, effects of forward and reverse recovery time, series and parallel connected diode, Multiphase star rectifier, Three-phase bridge rectifier, Three-phase bridge rectifier with RL load, Effects of source and load inductance.
2. **Thyristor and Controlled Rectifiers:** Thyristor types, series and parallel operation of thyristors, Programmable Unijunction Transistor, Principle of phase-controlled converter operation, single phase semiconverters, single phase full converters, single phase dual converter, Three phase half-wave converter, three phase semiconverter, three phase full and dual converters, power factor improvement. Thyristor commutation technique, natural commutation, forced commutation.
3. **AC voltage Controllers:** principle of off-on control, principle of phase control, single-phase bi-directional converter with resistive load, three –phase half wave and full wave controller, three phase bi-directional Delta connected controllers, cycloconverters, AC voltage controllers with PWM control.
4. **Power Transistor:** Bipolar junction transistor, MOSFETs, SITs, IGFETs (switching characteristics and switching limits), series and parallel operation.
5. **DC chopper:** principle of step-down operation, step-down chopper with RL load, chopper classification, switching-mode regulators, Thyristor chopper circuit, Applications.
6. **Pulse width-modulated inverters and resonant pulse inverters:** Principle of operation of pulse width inverters, three phase bridge inverters, voltage control of single and three phase inverters, series and parallel resonant inverters, class E resonant inverter.
7. **DC and AC drives:** Basic characteristics of DC motors, operating models, single phase drives, three phase drives, chopper drives, induction motor drives, synchronous motor drives, Applications.
8. **Protection of devices and circuits:** Cooling and heat sinks, snubber circuits, reverse recovery transients, supply and load side transient, voltage protection by selenium diode and metal oxide varistors, current protection.

Books recommended:

1. Power Electronics : Muhammad H. Rashid
2. Power Electronics : Mohan/Undeland/Robbins
3. Power Electronics : P C Sen

APE-5006 DIGITAL ELECTRONICS AND PULSE TECHNIQUES

1. **Digital Electronics-An Overview:** Analog and digital world; Number system; Logic gates; De Morgan's theorems; The universal building block; Laws and theorems of Boolean algebra; Boolean functions; Simplification of Boolean functions; XOR and XNOR gates; TTL circuits.

2. **Simplifying Logic Circuits:** Minterm and maxterm; SOP and POS circuits; Algebraic simplification; Map method: Truth table to Karnaugh maps; Simplifications; Tabulation method: Determination and selection of Prime- Implicants.

3. **Arithmetic Circuits:** Complements: The r's and (r-1)'s complements; Subtraction with r's and (r-1)'s complements; Adders: half-adder and Full-adder; Binary parallel adder, Decimal adder, BCD adder; Subtractors: Half-subtractor and full subtractor; Binary Multiplier.

4. **Flip-flops and Related Devices:** NAND and NOR latch; SR flip-flop; D-type flip-flop; JK flip-flop; JK master-slave flip-flop; Counters: 4-bit binary counter, Binary ripple counter; Synchronous counter, Parallel Counter; Combination counter; Binary decade counter; BCD counter; Serial shift register; BCD shift registers.

5. **Decoding and Encoding:** Decoder; BCD to 7 segments decoder; BCD to decimal decoder; Encoder; Multiplexing and demultiplexing; Multiplexer and Demultiplexers.

6. **Converters:** Digital to analog converter: Variable-resistor network; Binary ladder, D/A converter; D/A accuracy and resolution; Analog to digital converter: Simultaneous Conversion; Counter method; Successive Approximation, A/D accuracy and resolution.

7. **Semiconductor Memories**: Memory organization and operations; Classification and characteristics of memory; memory technologies: RAM; SRAM; DRAM; SDRAM ROM; PROMS and EPROMs.

BOOKS RECOMMENDED

1. Malvino, A. P., and Leach, D. P.; Digital Principles and Applications; Tata McGraw-Hill Publishing Company.
2. Malvino, A. P.; Digital Computer Electronics; Tata McGraw-Hill Publishing Company.
3. Mano, M. Morris; Digital Logic and Computer Design.
4. Tocci; Digital Systems, Principles and Applications; Prentice Hall of India Pvt. Ltd.
5. Nashelsky, L.; Introduction to Digital Computer Technology.

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APE-5007: OPTOELECTRONICS AND OPTICAL INTEGRATED CIRCUITS

1. **Optical properties in semiconductor**: Direct and indirect band-gap materials, basic transitions in semiconductors, radiative and nonradiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation. Optical properties of materials for integrated optoelectronics (IO) and photonics (IP), advantage of optical integrated circuits (OICs), passive optical structures and devices for integrated optics.
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2. **Light emitting diode (LED):** Principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers. Double-Hetero-structure (DH) LEDs, Characteristics, Surface and Edge emitting LEDs.Stimulated emission and light amplification: Spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions.
3. **Semiconductor Lasers:** Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, elementary laser diode characteristics, heterojunction lasers, optical and electrical confinement. single frequency solid state lasers-distributed Bragg reflector (DBR), distributed feedback (DFB) laser.

4. **Photo-detectors:** Photoconductors, junction photo-detectors, PIN detectors, avalanche photodiodes, hetero-junction photodiodes, Schottky photo-diodes and phototransistors. Noise in photodetectors. PIN and APD. Photo-detector design issues. Solar cells: Solar energy and spectrum, silicon and Schottkey solar cells.
5. **Modulation of light:** Phase and amplitude modulation, electro-optic effect, acousto-optic effect and magneto-optic devices. Introduction to integrated optics.
6. **Types of optical waveguides,** materials and optical waveguide fabrication techniques, design of OIC elements (optical switch, optical directional coupler, light divider, light combiner, optical polarizer, and optical isolator), optoelectronic modulators- electro-optically controlled devices properties and technology.
7. **Semiconductor materials and structures:** applicable for integrated optoelectronics. Active semiconductor devices based on heterostructures, quantum wells and superlattices applicable for integrated optoelectronics. Integrated optoelectronic transmitters and receivers for optical communication systems. Integrated optoelectronic optical systems for recording, processing and display the information.

Books:

1. Nonlinear Optics, 2nd or 3rd Edition Robert W. Boyd
2. Photonics: Optical Electronics in Modern Communications, 6th Edition Amnon Yariv and Pochi Yeh
3. Application of Nonlinear Optics 5th Edition Agrawal

APE-5008: DIGITAL SIGNAL PROCESSING

1. **Multirate Digital Signal Processing:** Multirate processing, fundamentals of decimation and interpolation, methods for optimizing processing throughput requirements via multirate designs, multirate techniques in filter banks, spectrum analyzers and synthesizers, structures and network theory for multirate digital systems.
2. **Finite Arithmetic Error Analysis:** Analog-to-Digital conversion errors, quantization effects of finite arithmetic for common digital signal processing algorithms including digital filters and FFTs, methods of calculating the noise at the digital system output due to arithmetic effects.
3. **Linear Prediction theory:** Representation of a stationary random process, discrete random signals, moments, bias-variance, linear stochastic models, ARMA (Auto Regressive Moving Average) modeling, properties of estimators bias/variance, Cramer Rao Lower Bound , MVU (Minimum Variance Unbiased) estimator, BLUE (Best Linear Unbiased Estimator), ML (Maximum Likelihood) estimation, Bayesian estimation, Forward and Backward Linear Prediction, Levinson-Durbin Algorithm, Properties of the Linear Predictors, The Concept of a Whitening Filter
4. **Power Spectrum Estimation:** Estimation of Autocorrelation and Power Spectrum of Random Signals, Non Parametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation
5. **Statistical signal processing:** Orthogonality principle, block and sequential forms, Wiener filter, adaptive filtering, Recursive Least Squares Estimation, Kalman Filter Theory, Adaptive Algorithms: LMS, RLS and their variants, Joint Multichannel Least Squares Lattice, Spatial filtering of equally and unequally spaced arrays.
6. **Applications:** Acoustic echo cancellation, signal enhancement, inverse system modelling, denoising.

References:

1. Digital Signal Processing: A computer-based approach, Sanjit K. Mitra, McGraw-Hill, 3rd edition, 2005.
2. Digital Signal Processing - Principles, Algorithms and Applications, John G. Proakis and Dimitris G. Manolakis, Macmillan, New York, Third edition,1996.
3. Theory and Application of DSP, L.R. Rabiner and B. Gold.
4. Discrete-Time Signal Processing, Oppenheim, Schafer & Buck, Prentice-Hall, New Jersey, 2nd edition, 1999.

APE 5009 IMAGE PROCESSING AND PATTERN RECOGNITION

1. **Introduction:** Digital image, Steps in digital image processing, Components of an image processing system, Application of digital image processing, Image sampling and quantization, Basic relationships between pixels.
2. **Intensity Transformations and Spatial Filtering:** Basic concepts, Intensity transformation functions, Histogram processing, Mechanics of spatial filtering, spatial correlation and convolution.

3. **Filtering in the Frequency Domain:** Preliminary concepts, Extension to functions of two variables, Properties of 2-D DFT**,** Discrete cosine transform, Filtering fundamentals, Steps for filtering Image smoothing, Image sharpening, Image restoration, Noise models, Noise reduction, Inverse filtering, Wiener filter.
4. **Wavelets and Multiresolution Processing:** Background, Haar transform, Multiresolution expansions, Wavelet transforms.
5. **Image compression:** Fundamentals of image compression, Coding redundancy, Spatial and temporal redundancy, image compression model, Huffman coding.
6. **Morphological Image Processing:** Erosion, Dilation, Opening, Closing, Basic morphological algorithms-Boundary extraction, Hole filling, Skeletons.
7. **Image Segmentation and Color Image Processing:** Basic concepts, Point, linc, and edge detection, Thresholding, Region-based segmentation, Color models, Color transformations.
8. **Pattern Recognition:** Patterns and pattern classes, Recognition based on decision-theoretic methods, Basic model of a neuron, Perceptron, Neural networks, Learning methods.

Books Recommended:

1. Digital Image Processing : Rafael C. Gonzalez, Richard E. Woods
2. Image Processing, Analysis and Machine Vision
3. Millan Sonka, Vaclau Hlavac, Roger Boyle

APE-5010 DATA COMMUNICATION AND COMPUTER NETWORKING

1. **Network Fundamentals and Internet overview:** Network Architecture; Performance; Network Elements; Ethernet (802.3), Rings (802.5, FDDI, RPR),

2. Wireless (Bluethooth, Wi-MAX, Wi-Fi, Cell Phone Technologies); Simple Internetworking (IP); Router Architecture; Routing Algorithms.

3. **Internetworking:** Protocols: RIP, OSPF, BGP, Metrics; Routing for Mobile Hosts; Global Internet; Subnetting: CIDR, VLSM, BGP; IPv6 details; Multicast; Multiprotocol Level Switching; Multiplexing and Demultiplexing; UDP, TCP, RPC, Transport for Real Time (RTP) Protocol.
4. **Section - B**
5. **Congestion Control and Resource Allocation:**Issues in Resource Allocation; Queuing Disciplines: FIFO, Fair Queue; TCP Congestion Control; Congestion-Avoidance Mechanisms; Quality of Service: Application Requirements, Integrated Services (RSVP), Differentiated Services (EF, AF), Equation-Based Congestion Control.

6. **Advanced Issues:** Overlay Networks: Routing overlay, Peer-to-peer network, Content Distribution Network; Network Virtualization; Datacenter and Cloud; Ubiquitous network; Software Defined network.

BOOKS:-

APE-5011 COMMUNICATION ENGINEERING AND SATELLITE COMMUNICATION

a. **Wireless Communication system:** 2G, 2.5G, 3G, 4G & 5G of wireless networks, GSM, WiMAX, WiFi; Wireless local loop and LMDS; Multiple access, FDMA, TDMA, CDMA, WCDMA, SDMA; Wireless system & standards.

b. **Cellular Concept-system design fundamentals**: Introduction, frequency reuse; Channel assignment and handoff strategies, Interference and system capacity; Power control for reducing interference; Trunking & GoS; Improving coverage & capacity in cellular

system; Digital cellular system; Global System for Mobile (GSM); North American TDMA and CDMA.

c. **Radio propagation model**: Free space propagation model, Diffraction model, Log-distance path-loss model,, Hata-Okumma model, PCS micro cell model, Indoor propagation models; Small-signal fading and multipath propagation; Types of small-scale fading, Fading effect due to multipath, Time delay spread and Doppler spread; Rayleigh and Rician distributions.

d. **Equalization, Diversity & Channel coding:** Fundamentals of equalization, Equalization in communication receiver, Algorithm for adaptive equalization, Diversity technique, Channel coding, RAKE receiver, Block codes, Convolution codes.

Section – B

a. **Modulation techniques for Communications:** Introduction to digital communication, pulse modulation, Sampling and multiplexing; Digital modulation, BPSK, DPSK, QPSK, QPSK transmission and detection techniques; System noise; Spread spectrum modulation techniques.
b. **Baseband Transmission:** Introduction, Baseband center point detection, Error accumulation over multiple hops, Line coding, Multiplex telephony, Digital signal regeneration, Symbol timing recovery, Repeater design.

c. **Information theory and source coding:** Information and entropy, Conditional entropy and redundancy, Information loss due to noise, Source coding, Variable length coding, Source coding examples.

d. **Error control coding:** Introduction, Hamming distance and code word weight, (n, k) Block codes, Encoding of conventional codes, Practical coders.

Books Recommended:

Text Books:

1. Wireless Communications : Theodore S. Rappaport
2. Digital Communications : Ian Glover, Peter Grant, Prentice-Hall Inc.

Reference Books:

1. Principles of wireless networks : Kaveh Pahlavan & Prasant Krishnamurty
2. Wireless Communication : Andrea Goldsmith
3. Mobile Cellular Telecommunication : William C. Y. Lee

APE- 5012 RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT

1. **Hydrogen and Fuel Cells:** Basics of electrochemistry, Fossil fuels and environmental impact, Polymer membrane electrolyte (PEM) fuel cells, Solid oxide fuel cells (SOFCs), Hydrogen production and storage, Coal-fired plants and integrated gassifier fuel cell (IGFC) systems.

2. S**olar Energy:** Solar radiation, Solar thermal energy, Photovoltaics (Solar cells), CO2 capture and solar fuels.

3. **Biomass and Bio-energy:** Synthetic fuels from the biomass, Thermo-chemical, physical-chemical and bio-chemical conversion, Bio-fuel cells.

4. **Wind Energy and Hydroelectricity:** Availability of wind energy, Wind turbines, wind parks and power control, Water sources and power, Water turbines and hydroelectric plants, Energy storage.

Books Recommended:

1. Renewable Energy, Power for a Sustainable Future, Oxford University Press, 2004, ISBN-13: 978-0199261789 Godfrey Boyle
2. Advanced Renewable Energy Sources, Royal Society of Chemistry, 2011
3. G. N. Tiwari and R. K. Mishra, Renewable Energy: Physics, Engineering, Environmental Impacts, Economics & Planning, 2010 Bent Sorensen

PHY-5013 RADIATION PROTECTION AND NUCLEAR MEDICINE

1. **Interaction of Radiation with Matter:**
   Alpha-, Beta-rays, Range-energy relationships, Mechanisms of energy loss (ionization and excitations, Bremsstrahlung); Gamma Rays: Exponential absorption, Interaction mechanisms of Radiation with matter, Neutrons: Production, classification, Interaction:Scattering, absorption, neutron activation.

2. **Radiation Dosimetry:** Radiation units, Exposure-dose relationship, Bragg-Gray principle, Kerma, Calculation of dose rate from different sources, effective half-life, Total effective dose.

3. **Radiation Detection:** Scintillation detector, Semiconductor detectors, TLD, Neutron detection.

4. **Biological Effects of Radiation:** Acute effects, delayed effects; Relative biological effectiveness (RBE) and quality factor (QF); Dose Equivalent; Total effective dose, Mechanism of interaction of radiation with Cells; Exposure and entry mechanism of radiations to Human body.

5. **Radiation Protection Guide:** Principle of radiation protection, Basic radiation safety criteria, Exposure of individuals in the general public, Allowable limit on intake of radiation, Typical rules of operation for a radiation laboratory.

6. **External Radiation Protection:** Basic Principles; Techniques of External Radiation Protection: Time, distance, shielding, X- and gamma-ray shielding, Beta ray shielding, neutron shielding.

7. **Internal Radiation Protection**: Internal radiation hazard: Principle of control, Control of source, Environmental monitoring and control, Protective clothing, Respiratoryprotection, Surface Contamination limits.

References:

1. H. Cember, Introduction of Health Physics, McGraw-Hill, 1992.
2. Martin and Halison Introduction to Radiation protection
3. D. Hughes, Notes on Ionising Radiation, Quantities, Units, Bilogional Effects and Permissible Doses, Science Reviews Ltd., London and H. Scientific Constants Limited.

APE-5014 : QUANTUM COMPUTATION AND INFORMATION

1. **Introduction to quantum mechanics:** Hilbert space, Unitary and stochastic dynamics, Probabilities and measurements, Entanglement, Density operators and correlations, Quantum computation: Single Qubit operations, Controlled operations, Universal quantum gates, Quantum circuit model, Simulation of quantum systems, Quantum Fourier transform and its application.
2. **Different quantum computers:** Physical realization
3. **Quantum algorithms:** Classical computation, Shor factorization, Grover search, Measurement-based computation
4. **Quantum information**: Classical information theory, Quantum information types and quantum channels, Dense coding, Teleportation, No cloning, Quantum cryptography
5. **Quantum Noise and quantum operations:** Classical noise and Markov processes, Quantum operations, Examples of quantum Noise and quantum operations, Applications of quantum operations, Limitations of the quantum operations formalism.
6. **Quantum error correction:** Graph states and codes, The Shor code, Quantum error correction, Fault-tolerant computation
7. **Quantum information theory:** Data compression, Quantum cryptography.

BOOKS: **References:**

1. C. Itzykson and J.-B. Zuber, Quantum Field Theory.
2. J.D. Bjorken and S.D. Drell, Relativistic Quantum Fields.
3. L. Ryder, Quantum Field Theory.

PHY-5015: NANO - PHYSICS & NANO -TECHNOLOGY

1. Basic Properties of Nanoparticle: Particle size; Top down and bottom up ideas, Particles shape; Size effect and properties of nanoparticles; Particle density; Melting point; Surface tension; Specific surface area and pore; Composite structure; Crystal structure; Surface characteristics; Mechanical properties; Electrical properties; Magnetic properties; Optical properties; Applications of vacuum technology.

2. Scanning Tunneling Microscopy (STM): Fundamentals: Introduction of STM, band structure effects; Coulomb blockade and single electron tunneling; Elastic; Inelastic; Spin-polarized tunneling, Role of tip geometry; Lithography and atomic manipulation; Information extracted: spectroscopy at the nanoscale, Electronic surface density of states; Basic Operation: Constant current and constant voltage modes.

3. Atomic Force Microscopy (AFM): Fundamentals: Attractive or repulsive tip-sample interactions, Van der Waals force; Electrostatic force; Magnetic force; Force spectroscopy; Nanotribology. Information extracted: Real-space morphological images with nearly atomic resolution of conducting and non-conducting nano-materials, Charge distribution in polymer surfaces; Basic operation: Tapping, non contact and contact modes.

4. Nanostructure Electronic and Chemical Characterization: X-ray Photoelectron Spectroscopy (XPS): Fundamentals: Photoelectric effect, binding energy and chemical shift, spin-orbit splitting, initial and final state effects, Information extracted: Surface composition and chemical state of surface species; Ultraviolet Photoelectron Spectroscopy (UPS): Information extracted: Band structure, Fundamentals of Fourier transform infrared radiation (FTIR) and Raman spectroscopy.

5. Nano Systems: An artificial and tunable atom (quantum dot); Quantum wire; Quantum Hall effect; Carbon nano-tube; Tunnel diode; Molecular transistor; Single electron transistor; Spin polarized transistor; Thin films; Self assembly.

BOOKS RECOMMENDED

1. Roland Wiesendanger; Scanning Probe Microscopy and Spectroscopy – Methods and Applications; Publisher: Cambidge University Press (1994).
2. Joel I. Gersten, Frederick W. Smith; The Physics and Chemistry of Materials; Publisher: John Willey and Sons, Inc. (2001)
3. B. Bhushan, H. Fuchs, M.Tomitori; Applied Scanning Probe Methods IX Characterization (NanoScience and Technology); Publisher: Springer (2008).
4. John C. Vickerman; Surface Analysis (The principal Techniques); Publisher: John Wiley and Sons (2003).
5. Wolf, E.; Nanophysics and Nanotechnology, Wiley-VCH, (2006).
6. Bandyapadya, A.K.; Introduction to Nanotechnology.

APE-5016 : CONDENSED MATTER PHYSICS

Crystal Structure of Solids

Crystalline Materials; Glassy Forms Periodic Lattice; Lattice Translation Vectors; Lattice with A Basis – Central and Non-Central Elements; Primitive and Non-Primitive Crystal Axis; Unit Cell; Types of Lattices; Primitive and Conventional Bravais Lattice; Position, Directions and Planes in Crystals; Inter-planer Spacing; Miller Indices of Lattice Planes, Crystalline Periodicity, Crystal Symmetry, Point Groups and Space Groups; The Reciprocal Lattice Vectors; Examples - Fourier Representation. Brillouin Zones; Crystal Types, Examples of Crystal Structures; Simple, Body-Centred and Face-Centred Cubic Lattices; Hexagonal Closed Packed Lattices.

2. Crystallography

Diffraction of X-Rays by Crystals; The Bragg Diffraction Law, Theory of Laue Spots - Laue Condition of X-Ray Diffraction, Determination of Crystal Structure with X- Rays; Measurement of Lattice Parameter for Cubic Lattices; Diffraction Methods and Missing Orders; Scattering from Time Varying Structures; Atomic and Geometrical Factor.

3. Bonding in Solids

Types of Bonding in Solids; Covalent, Ionic Bindings; Energy of Bonding; Transition between Covalent and Ionic Bonding; Metallic Bonding; Vander Waal's Bonding; Hydrogen Bond; Interaction Potential for Atoms and Ions; Atomic Bonding in Inorganic and Organic Materials; Non-Crystalline States of Condensed Matter: Amorphous Solids, Liquids.

4. Lattice Dynamics & Specific Heat of Solids

1D Monoatomic and Diatomic Chains; Periodic Boundary Condition & Vibrational Modes of the 1- D Lattice; Phase and Group Velocity; Localized Modes; Phonons; Acoustical and Optical Phonons; Qualitative Description of the Phonon Spectrum in Solids; Lattice Heat Capacity; Classical Calculation of Lattice Specific Heat; Dulong and Petit's Law; Einstein and Debye Theories of Specific Heat of Solids, T^3 Law; Dispersion in 3D.

5. Free Electron Theory of Metals

Electrons in K-Space: Metals; Density of States; Fermi-Dirac Distribution; Heat Capacity; Transport Properties; Relaxation Time, Mean Free Path, Mobility and Thermal Conductivity; Drude Model – Electrical Conductivity; Wiedemann Franz Lorentz Relation; Nearly Free Electron Model; Hall Effect in Metals; Qualitative Description of Free Electron Theory and Its Inadequacies with Reference to Hall Effect and Specific Heat of Electrons in Metals; Elementary Concepts of Quantum Hall Effect; Structure and Scattering.

6. Energy Band Structure

Periodic Potential in a Crystalline Solid; Elementary Band Theory of Solids - Bloch's Theorem; Kronig-Penney Model and the Formation of Energy; Allowed and Forbidden Energy Gaps; Effective Mass of Electrons; Number of Electrons in a Band; Reciprocal Effective Mass Tensor of Electrons; Concept of Hole; Conductor, Semiconductor (p- and n-type) and Insulators; Conductivity of Semiconductor; Mobility; Hall Effect; Electron & Hole Mobilities; P-N Junction (Thermal Equilibrium); Measurement of Conductivity (04 Probe Method) & Hall Coefficient; Tight Binding Model.

7. Transport Phenomena

Phase and Group Velocity; Effective Mass; Scattering (Phonons, Electrons); Polaron; Boltzmann Equations; Heat Transport; Phonons; Electrons; Charge Transport (Conductivity); Electrons; Ions; Hall Effect and Quantum Hall Effect; Thermoelectric Effects; Electrical Conductivity According To Classical and Quantum Theory.

8. Dielectric Properties of Materials

Electric Susceptibility; Kramers Kronig; Oscillator Model; Local Field; Ferroelectricity; Plasmons; Polaritons; Screening; Interband Transitions; Excitons; Static Dielectric Constant of Solids; Dipole Moment and Polarization; Types of Polarization –Electronic; Ionic and Orientational Polarizations; Local Electric Field at an Atom; Depolarization Field; Polarizability; Clausius Mosotti Equation; Classical Theory of Electric Polarizability; Normal and Anomalous Dispersion; Cauchy and Sellmeir Relations; Langevin-Debye Equation; Complex Dielectric Constant.

9. Magnetic Properties of Solids

Definitions Of Diamagnetism; Paramagnetism; Ferromagnetism; Magnetic Moments; Magnetic Susceptibility; Diamagnetism Of Core Electrons; General Treatment Of Paramagnetism; Larmor

Diamagnetism; Hund's Rules; Pauli Paramagnetism; Heisenberg Model; Mean Field Theory; Spin Waves; Giant And Colossal Magnetoresistance; Classical Langevin Theory Of Dia– And Paramagnetic Domains; Quantum Mechanical Treatment Of Paramagnetism; Curie's Law; Discussion Of B-H Curve; Hysteresis And Energy Loss; Electrostatic Origin Of Magnetic Interaction; Magnetic Properties Of A Two electron System; Heitler-London Theory; Connection With Spin Hamiltonian -Antiferromagnetism; Quantum Theory Of Paramagnetism (For S=1/2 System); Ferromagnetism : Spontaneous Magnetization And Ferromagnetic Properties Of Solids; Heisenberg Hamiltonian; Ground State; Excited States; Weiss Molecular Field Theory (Mean Field); Temperature Variation Of Spontaneous Magnetization Curie-Weiss Law; Domain Structure & Hysteresis In Ferromagnets; Measuring M-H Loops; Technological Uses Of Magnetic Materials; Magnetic Resonance.

10. Superconductivity

Phenomenology; Experimental Observations; Critical Temperature; Critical Magnetic Field; Meissner Effect; Type I and Type II Superconductors; London's Equation and Penetration Depth; Isotope Effect; Ginzburg-Landau Theory; BCS Theory; Josephson Junctions; High Temperature Superconductors; Applications of Superconductivity; Properties of the Superconducting State; Origins of Magnetism in Materials; Applications of Superconductivity and Magnetism.

Reference Books

1. Introduction to Solid State Physics; Charles Kittel; 8th Edition; 2004; Wiley India Pvt; Ltd;
2. Introduction to Solids; Leonid V; Azaroff; 2004; Tata Mc-Graw Hill
3. Ashcroft N;W; and Mermin N;D; : Solid State Physics; Holt Reinhert and Winston
4. Blackmore J;S; : Solid State Physics
5. Dekker A;J; : Solid State Physics; Prentice Hall

APE-5017: PLASMA SCIENCE AND TECHNOLOGY

1. Introduction: Existence of plasma in space, magnetic fields in space; Solar radiation, solar atmosphere, solar activity, solar wind, heliosphere, solar sails; Motion of charged particles in magnetic fields; The magnetospheres, radiation belts, ionospheres and plasmaspheres of the Earth and other celestial bodies.

2. Linear waves in plasmas: Ion-acoustic waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Lower hybrid waves: Basic concept, Derivation of lower-hybrid frequency, Physical interpretation; Upper-hybrid waves: Basic concept, Derivation of upper-hybrid frequency, Physical interpretation; Shear Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Compressional Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation.

3. Nonlinear Solitary Waves in Plasmas: Solitary waves; Ion-acoustic solitary waves: Derivation of Korteweg-de Vries (K-dV) equation, Stationary solitary wave solution of K-dV equation, Physical interpretation.

4. Nonlinear Shock Waves in plasmas: Shock waves; Ion-acoustic shock waves: Derivation of Burgers equation, Stationary shock wave solution of Burgers equation, Physical interpretation.

5. RF Discharge: Charging of Insulator Surfaces, Application of AC Discharges, Self-Bias, The Efficiency of Discharges, Sheaths-Collisions and Modulation, Matching Networks, Voltage Distribution, Application to Sputtering and Reactive Ion Etching Systems, Application to Planar Diode Reactors, Symmetrical Systems, Asymmetric Systems, Measurement of Plasma Potential, Equivalent Circuits, Plasmoids.

6. Chemical Reactions and Chemical kinetics: Introduction, Energy and Enthalpy, Entropy and Gibs free Energy ,Chemical Equilibrium, Elementary Reactions, Relation to Equilibrium Constant, Gas Phase Kinetics, First Order Consecutive Reactions, Opposing Reactions, Bimolecular Association with Photon Emission.

7. Sputtering and Plasma Etching: Interactions with Surfaces, Applications of Sputtering, Practical Aspects of Sputtering Systems, Plasma Ashing, Plasma Etching, Reactor Systems, Etching Mechanisms, Selective Etching and Plasma Polymerization, Chemical Dry Etching.

8. Applications of Plasmas: Lighting Systems, Display Technology, Environmental Application, Plasma Medicine, Textile Engineering, Sterilization, Thin Film Deposition, Coating, Surface Modification, Switch, Relay, Power System.

BOOKS RECOMMENDED

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion (Plenum, New York, 1984).
2. P. K. Shukla, and A. A. Mamun, Introduction to Dusty Plasma Physics (Institute of Physics Publishing Ltd., London, 2002).
3. W. Baumjohann and R. A. Treumann, Basic Space Plasma Physics, (Imperial College Press & World Scientific, 1997).
4. R. A. Treumann and W. Baumjohann, Advanced Space Plasma Physics, (Imperial College Press & World Scientific, 1997).
5. Cravens, Thomas E. Physics of solar system plasmas, (Cambridge: Cambridge University Press, 1997).

APE-5018 BIOMEDICAL PHYSICS

Section A: Biophysics

1. **Properties and Structure of Macromolecules:** Atomic and molecular forces; Nucleic Acids (DNA, RNA); Methods of replication; Amino-acids.

2. **The Cell Membrane:** Properties of membrane; Transport and diffusion of ions and molecules through the cell membrane; Basic physics of membrane potentials; Measurement of membrane potentials; Membrane model.

3. **Neuromuscular Physics:** Overview of the central nervous system; Origin of resting and action potentials in neurons and muscle fibers; Propagation of action potentials through neuromuscular system; Huxley-Hodgkin theory; Neurotransmitters.

4. **Physics of the Cardiovascular System:** Introductory concepts; Bernoulli's principle applied to cardiovascular system; Generation of Korotkoff sound and indirect measurement of blood pressure.

Section –B: Medical Physics

5. **Physics of the Heart:** Electrical activity of hear; ECG/EKG measurement; Typical waveforms and physiological origins of the major peaks in the wave form; Artificial pacemaker.

6. **Imaging Techniques:** Nature, Production and detection of ultrasounds; A-scan, B-scan, M-scan, CT, MRI and gamma camera; Clinical applications.

7. **Nuclear Medicine:** Principle, choice of radionuclide and radiopharmaceuticals; Technetium generator; Imaging and function test of thyroid gland, liver, spleen, kidney, lungs, brain, heart, and bone.
8. **X-rays and Radiation Therapy:** Production and clinical applications of X-rays; Principles of radiation therapy; Radiotherapy treatment planning; Isodose curve; Simulator; Teletherapy; Brachytherapy.

BOOKS RECOMMENDED

1. Brown B.H. and Small Wood R.H.; Medical Physics and Physiological Measurements.
2. Cameron J.R. and J. Skofronick; Medical Physics.
3. Brown B.H. and Small Wood R.H, D.C Barber P V Lawford and D R Hose; Medical Physics and Biomedical Engineering.
4. Johns and Cunnighum; Physics of Radiology.
5. Cesareo, R. et al.; Nuclear Analytical Techniques in Medicine.

APE-5019 : Laser Physics

1. **Basic concepts of energy-level** manifolds in gain media, particularly in respect of population inversion and saturation effects; conditions for oscillator stability in laser resonator configurations and transverse and longitudinal cavity mode descriptions; single longitudinal mode operation for spectral purity and phase locking of longitudinal modes for the generation of periodic sequences of intense ultrashort pulses (i.e. laser modelocking); illustrations of line-narrowed and modelocked lasers and the origin and exploitability of intensity-induced optical effects.

2. **Transient/dynamic behaviour of laser oscillators** including relaxation oscillations, amplitude and hase modulation, frequency switching, Q-switching.

3. **Cavity dumping and mode locking;** design analysis of optically-pumped solid state lasers; laser amplifiers including continuous-wave, pulsed and regenerative amplification; dispersion and gain in a laser oscillator-role of the macroscopic polarization; unstable optical resonators, tunable lasers.

4. **Optically pumped solid state laser:** Optical pumping in three and four level lasers, effective lifetime of the levels involved, threshold inversion in three and four level lasers, quantum efficiency, pumping power, threshold lamp power, threshold for pulsed operation of a Ruby laser, threshold for CW operation, threshold population inversion and stimulated emission, the Nd:Yag laser, the Nd^{3+} glass laser.

5. **Gas laser:** Optical pumping, Electron impact excitation, The Argon-Ion laser, pumping saturation in gas laser system, pulsed ion lasers, CW ion laser.

6. **Semiconductor laser:** Introduction to semiconductor Physics background, Recombination and luminescence, spectrum of recombination radiation, external quantum efficiency, Hetero-junctions, Ternary and quaternary lattice matched materials, energy barriers and rectifications, double hetero-structure, semiconductor laser, gain coefficient of a semiconductor laser, estimation of semiconductor laser gain, threshold current and power voltage characteristics, longitudinal and transverse modes, semiconductor laser structures, DFB and DBR lasers, surface emitting lasers, QW lasers.

BOOKS RECOMMENDED

1. Laser Physics 1st Edition by Peter W. Milonni (Author), Joseph H. Eberly (Author)
2. Lasers Revised ed. Edition by A. E. Siegman (Author)

APE-5020: PHYSICS OF DATA AND DATA ANALYSIS

1. **Introduction:** Introductory concepts of Data, information and Knowledge, Types of Digital Data, Introduction to Big Data, Big Data Analytics, Analytics, Big data life cycle, Role of Big data Analytics. Data Source and applications at different domain. Privacy, Approach and Ethics.

2. **Prepressing and EDA:** Know your data types, characteristics, acquisition technique and preprocessing. Basic mathematics and statistics required to handle Machine Learning algorithm and Big data analytics.

3. **Introduction to Machine Learning:** Data Analytics with Python,Supervised Learning, Unsupervised Learning, Collaborative Filtering, Introduction to Regression and its types, K-NN, Generative Classification, Discriminative Classification,Time Series data and Time Series data analysis,Dimensional Reduction, PCA, NMF, and ICA, Nonlinear Dimensional Reduction, Manifold Learning, and tSNE, Mixture of Gaussians, Kernels, Clustering, Reinforcement Learning and Evaluation.

4. **Basic Statistics and Python:**Basic statistical concepts with a brief review of Python. Introduction to Scikit-Learn. Implementation of various methods of Regression, Classification and Clustering methods using Scikit-Learn.

5. **Big Data Technologies - HDFS**: The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and

Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures

6. **Big Data Technologies - Spark:** Introduction to Spark, the dominant mainstream framework for processing of large data volumes on large computational clusters. Formulation of calculations so that they could process big data in batch mode.

Text book and References:

1. Data Science and Big data Analytics, EMC Education Services.
2. Machine Learning with Spark, Nick Pentreath, Packet Publishing.
3. Big Data, Data Mining, and Machine Learning, Jared Dean, Wiley.
4. The Elements of Statistical Learning by Hastie, Tibshirani, and Friedman, Springer.
5. Big Data and Business Analytics, Jay Liebowitz, Auerbach Publications, CRC press, 2013.
6. Hadoop: The Definitive Guide, Tom White, Third Edition, O'reily Media, 2012.
7. Big Data Glossary,Pete Warden, O'Reily, 2011.
8. Harness the Power of Big Data The IBM Big Data Platform, Paul Zikopoulos, Dirk DeRoos, Krishnan Parasuraman, Thomas Deutsch, James Giles, David Corigan, Tata McGraw Hill Publications, 2012.

APE-5021 NUCLEAR & REACTOR ENGINEERING

1. **Neutron:** Discovery; Sources of neutrons; Properties of neutrons; Neutron reaction; Slow neutron reaction; Neutron cross section; Microscopic and macroscopic cross sections; Determination of cross section; Mean free path; Attenuation of Neutrons; Neutron flux; Reaction rate; Classification of neutron according to energy; Energy dependence of neutron cross section; Fission cross section.

2. **Nuclear Reactors:** Classification of reactors according to the mean energy of neutrons causing fissions; Classification of reactors according to the material used; Classification by structure; Classification of reactors according to the purpose; Basic components of a nuclear reactor**:** Reactor core, cladding, coolant, moderator, control rod or control system, blanket, reflector, reactor vessel, shielding, reactor building.
3. **Nuclear Fission:** Classification of fissile; Fissionable materials; The mechanism of fission; Practical fission fuels; Products of fission; Yields and mass distribution of fission products; Energy distribution of fission fragments; Energy release from fission; Neutron yield and neutron production ratio; Prompt and delayed neurons; Energy distribution of fission neutrons; Reactor power; Fissions rate; Fuel burn up; Fuel consumption.

4. **Moderation or Slowing Down of Reactor Neutrons:** Neutron moderation by elastic scattering; Collision kinematics; Differential elastic scattering cross section; Isotropic scattering; Scattering angles in L and C.M systems; Angular and energy distribution; Forward scattering in the L System; Average energy loss per collision and average cosine of scattering angle; Average logarithmic energy decrement; Description of the dynamics of elastic collision in terms of lethargy; Transport mean free path and transport cross section; Slowing down power and moderating ratio; Slowing down time; Slowing down density; Resonance escape probability; The effective resonance integral.

5. **Neutron Diffusion:** Neutron transport equation: Basic definitions, assumptions; derivation

of transport equation; Meaning of neutron diffusion; Fick's law, Equation of continuity, One speed diffusion equation; Steady-state diffusion equation, boundary conditions, solution of diffusion equation for different geometry; The thermal diffusion length; The exponential piles; The diffusion length for a fuel moderator mixture; Multi-region problem; Fast neutron diffusion and Fermi age equation; Assumptions; Slowing down density and derivation of Fermi age equation, Fermi age, τ; Fast diffusion length, L_f; Physical significance of age, τ; Migration area and length.

6. **Neutron Chain Reaction:** Introduction; Neutron cycle and multiplication factors; Four factor formula; Neutron leakage and critical size; Six factor formula; Nuclear reactors and their classifications; Homogenous and heterogeneous reactor system; Effect of heterogeneous arrangement on η, p, f, and ε.

7. **Moderation or Slowing Down of Reactor Neutrons:** Neutron moderation by elastic scattering; Collision kinematics; Differential elastic scattering cross section; Isotropic scattering; Scattering angles in L and C.M systems; Angular and energy distribution; Forward scattering in the L System; Average energy loss per collision and average cosine of scattering angle; Average logarithmic energy decrement; Description of the dynamics of elastic collision in terms of lethargy; Transport mean free path and transport cross section; Slowing down power and moderating ratio; Slowing down time; Slowing down density; Resonance escape probability; The effective resonance integral.
8. **Reactor Control:** Control and reactor kinetics; Fission product poisoning, 135Xe poisoning, 149Sm poisoning; Control rod worth; Cylindrical rod; Burnable poisons; Effects of temperature on reactor kinetics; General feature of reactor control.

BOOKS RECOMMENDED

1. Enge, M.A; Introduction to Nuclear Physics.
2. Roy, R.R. and Nigam, B.P.; Nuclear Physics Theory and Experiment.
3. Knneth, S. Krane; Introductory Nuclear Physics.
4. Ghoshal, S.N.; Nuclear Physics.
5. Atam, P. Arya; Fundamentals of Nuclear Physics.

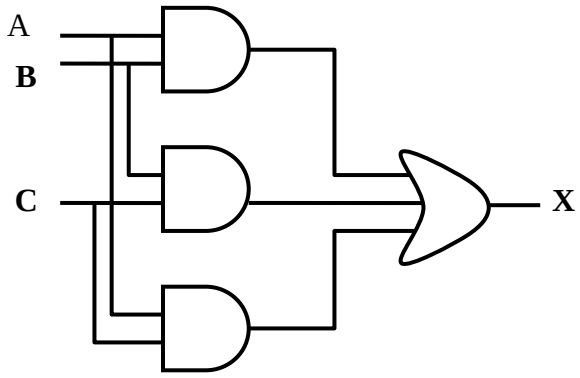
Physics Laboratory for Weekend Program

List of Experiments :

1. To determine the acceleration due to gravity, 'g' by a compound pendulum.
2. To determine the frequency of a tuning fork by Melde's apparatus.
3. Investigation of the principal types of optical spectra, calibration of the spectrometer and hence to determine the unknown wavelength.
4. Determination of the mechanical equivalent of heat, 'J' by electrical method.
5. To construct a half-wave bridge rectifier and observe the rectifying action of diode.
6. To study the output and transfer characteristics (with amplification factor) of a p-n-p (or n-p-n) transistor in common emitter circuit.
7. To determine the operation and characteristics of diode AND & OR gate (Using discrete components) (b) To determine the operation and characteristics of a typical

discrete component transistor logic gate.

8. To construct, Test and evaluate an IC Amplifier operated as a square-wave (Free-running square wave) oscillator and hence to:
   (i) measure the output voltage,
   (ii) determine the frequency by adjusting R between its limits,
   (iii) determine the frequency oscillation where it is dependent on the supply voltage for oscillation.
9. (a) To construct and study of a voltage series feedback amplifier using μA 741 IC and hence to find following:
   i. Gain with various combination of feedback,
   ii. Input resistance with feedback,
   iii. Output resistance with feedback,
   iv. To plot a frequency response curve and hence to find the 3 dB poin
   (b) To construct and study of a voltage follower by using above amplifier and to see the waveform on the oscilloscope.
10. (a) To verify the Associative Law, Distributive Law and De-Morgan's Law of Boolean Algebra.
    (b) To implement the given combinational logic circuit.



BOOKS RECOMMENDED

1. **Practical Physics** by Dr. Giusuddin Ahmad and Md. Shahabuddin
2. **Advanced Practical Physics by** Dr. Giusuddin Ahmad and Fatema Nasreen.
3. **Advanced Practical Physics for Students by** B. L. Worsnop and H. T. Flint

N.B.: The Department may include/exclude any experiment.

2018

Department of Physics

Handy guide to the MS Weekend Program Degree

MSUWP Booklet

To find out more about the Department of Physics visit following website:
www.juniv.edu/department/phy

This brochure has been drafted in advance of the academic year to which it applies. Every effort has been made to ensure that the information contained in this brochure is accurate at the time of publishing, but changes (for example to course content) are likely to occur given the interval between publication and commencement of the course. It is therefore very important to check our website for any updates before you apply for the course by following **www.juniv.edu/department/phy**. Where there is a difference between the contents of this brochure and our website, the contents of the website take precedence.

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