PRINCIPAL SUBJECT AREA

PHYSICS

400 LEVEL COURSES

PH 403 Classical Mechanics (2 credits)
(Prerequisite: PH 200)
Rotating coordinate systems, Motion of rigid bodies, Principle of least action and the derivation of Langrangram equations of motion. Applications. Galilean transformation and Lagrangian for a (i) free particle and (ii) system of particles; Mechanical similarity and viral theorem; conservation laws and symmetries in nature; constraints and method of Lagrange's undetermined multipliers; generalized force and generalized momentum; Hamiltonian and Hamiltonian equations of motion; simple application; Poisson bracket, Ehrenfert's theorem and integrals of motion; canonical transformations; Hamilton -Jacobi equation; adiabatic invariance and canonical variables.

Recommended Texts:
1. Landan, L. & Lifshtz, E M, *Mechanics* (1976), Pergamon press ltd, 3rd ed
2. Goldstein, *Classical Mechanics* (1980), Addision-Wesley publishing, 2nd ed
3. Desloge, *Classical Mechanics* (1982), John Wiley & sons, vol 1,2,3

PH 406 Statistical Physics (2 credits)
(Prerequisite: PH 205)
Introduction and Review: classical & quantum mechanics; thermodynamics; mathematics: probability distribution, binomial and multinomial distributions, Lagrange multipliers, binomial distribution at large numbers; Canonical and other Ensembles, fluctuations. Boltzmann, Fermi-Dirac and Bose-Einstein statistics, ideal monatomic and diatomic gases; Quantum statistics: weakly and strongly degenerate ideal Fermi-Dirac gas; photons;
Crystals: vibrational spectrum of monoatomic crystal; Einestein and Debye theories of heat capacity; phonons; point defects; Imperfect gases: Virial equation, Special Topics: Brownian motion; correlation functions; transport phenomena.

Recommended Texts:
1. Mc Quarrie, Donald A ., *Statistical Mechanics* (1973,1976), Hanper Colling Publishing
2. Reif, F., *Fundamentals of Statistical & Thermal Physics* (1965), McGraw Hill

PH 414 Lasers (1 credit)
Introduction: Properties of lasers, Stimulated emission, Population inversion, Amplification in a medium, Einstein coefficients; Laser Oscillation: Optical resonators, Concave mirrors and Brewster's windows, Resonant cavities, Coherence length, Frequency doubling; Types of Lasers: Gas lasers, He-Ne laser, Argon laser, Molecular laser, CO_2 laser, Solid state laser, Ruby laser, Nd-glass laser and other lasers; Laser Applications and Laser safety.

Recommended Texts:
1. Lengyel, B.A., *Introduction to Laser Physics* (1966), John Wiley
2. Marshall, S.L., *Laser Technology and Applications*.

PH 422 Magnetic Materials (2 credits)
(Prerequisite: PH 240)
Atomic theory of magnetism, Diamagnetism, Paramagnetism, Ferromagnetism and Antiferromagnetism. Ferromagnetic Domains, Application of ferromagnetic materials: magnetic bubbles and their uses; Magnetic resonance: paramagnetic resonance and the maser; magnetic relaxation; nuclear magnetic resonance (NMR); ferromagnetic resonance and spin waves.
Recommended Texts:
1. Ashcroft, N.W. and Mermin, N.D., *Solid State Physics* (1976), Saunders college publishing
2. Omar, M.Ali., *Elementary Solid State Physics* (1975), Addision-Wesley pubilishing com
3. Crangle, J., *Magnetic Properties of Solids* (1977), Edward Arnold

PH 423 Electromagnetic Theory (2 credits)
(Prerequisite: PH 323)
Electrostatics, Magnetostatics, Maxwell's Equations, Wave equation for Ø and A, Lorentz condition and gauge transformations; Poynting's theorem and Poynting's vector; electromagnetic momentum, Plane Electromagnetic Waves and Wave Propagation, Wave Guides and Transmission Lines, Generation of E.M. Waves.

Recommended Texts:
1. Grants and Phillip, *Electromagnetism* (1975), John Wiley & sons, 3rd ed
2. Griffiths, David J., *Introduction to Electrodynamics* (1989), Prentice Hall, 2nd ed.
3. Jackson, J.D., *Classical Electrodynamics* (1975), John Wiley & sons, 2nd ed

PH 430 Quantum Mechanics I (3 credits)
(Prerequisite: PH 230)
Review of Classical Mechanics, Hilbert space formalism of quantum mechanics. Schordinger, Heisenburg, and Interactive pictures. Wave mechanics in one, two, and three dimensions. Harmonic oscillator and Creation & annihilation operators, Angular momentum and Ladder method, Pauli's theory of spin, Total angular momentum.

Recommended Texts:
1. Weider, Sol., *The Foundation of Quantum Theory(1973),* Academic Press, Inc.
2. Series, Schaume .,*Quantum Mechanics* (1998), Schaum's outlines
3. Tanuigi, Cohen., *Quantum Mechanics,* (1977), John Wiley & sons, volume I

PH 431 Quantum Mechanics II (2 credits)
(Prerequisite: PH 430)
Methods of Approximation: Time independent and dependent perturbation theory, radiative transitions and Einstein coefficients. Variational technique, WKB approximation. Theory of scattering and many particle systems.

Recommended Texts:
1. Weider, Sol., *The Foundation of Quantum Theory*.
2. Tanuigi, Cohen., *Quantum Mechanics,* (1977), John Wiley & sons, volume I

PH 433 Nuclear and Reactor Physics (3 credits)
(Prerequisites: PH 230, PH 333)
Nuclear Properties; Nuclear force, Nuclear models, Nuclear reactions. Neutron Sources, Neutron Interactions, Energy loss in scattering collisions, Neutron Diffusion and Moderation, Nuclear Reactor Theory, Time-Dependent Reactor: Reactor kinetics: prompt neutron lifetime and mean diffusion time of thermal neutrons. Reactors with and without delayed neutrons; Reactor with delayed neutrons. Reactivity equation. The prompt critical state; the prompt jump (drop). Reactor control: control rods and chemical shims; Rod worth; Temperature effects on reactivity.

Recommended Texts:
1. Krane, K.S., *Introductory Nuclear Physics* (1998), John Wiley & sons
2. Evans, *Introduction to Nuclear Physics*.
3. Burcham, *Nuclear Physics* (1995), Longman group limited

PH 436 Radiation Detection and Measurement (2 credits)
(Prerequisite: PH 333)
Radiation Sources and Interactions, Counting Statistics, General Properties of Radiation Detectors, Radiation Detectors: ionization chambers; proportional counters; Geiger-Mueller counters; G-M survey meter; Scintillation detectors; Semiconductor detectors; Miscellaneous detectors: Cerenkov detector, Superconducting detectors, Photographic emulsions; Thermoluminescent dosimeters; Neutron detection by activation.

Recommended Texts:
1. Knoll, Glenn F. *Radiation Detection and Measurement - 2nd edition (1989),* John Wiley & sons
2. Leo, W.R., *Techniques for Nuclear and Particle Physics Experiments, 2nd edition.*
3. Hemingway, G.G.J., *Practical Gamma-Ray Spectrometry* (1995), John Wiley & sons

PH 440 Solid State Theory (3 credits)
(Prerequisite: PH 240)
Classical and quantum free electron models, Failures of free electron models, Review of crystal lattices and X-ray crystallography, Electrons in a periodic potential, Bloch's theorem, Nearly free electron model, Band gaps, Band structures, Fermi surfaces, Tight binding model, Empty lattice model, Semiclassical model of electron dynamics, Semiclassical motion under external electric and magnetic fields, Effective band mass, Concept of holes, Cyclotron motion, Measuring the Fermi surfaces, Landau levels, de Hass-van Alphen effect, Quantum Hall effect, Lattice Dynamics, Phonon modes, Superconductivity, Type I and Type II superconductors, Cooper pairs and BCS theory.

Recommended Texts:
1. Kittel, C., 7th *edition of Introduction to Solid State Physics* (1996), John Wiley & sons
2. Ashcroft, N.W. and Mermin, N.D., *Solid State Physics* (1976-Saunders College Publishing Co.)
3. Omar, Ali., *Elementary Solid State Physics* (1975), Addision-Wesley Publishing Co.
4. Myers, H.P., 2nd edition of Introductory Solid State Physics (1997), Taylor and Francis Publishers.

PH 445 Electronics Theory III (2 credits)
(Prerequisite: PH 345)
Gates and flip flops combined, Logic pathology, Logic families; RTL, DTL, TTL, CMOS, etc., TTL/CMOS characteristics, TTL/CMOS interfacing, Opto electronics; LED's CCD's, 7-segment, 16-segment and 5x7 dot matrix displays, driving LED displays, opto couplers; Data acquisition; sample and hold, noise and signal processing; A/D and D/A conversions, Digital filters; microprocessors and micro computers; computer architecture, microprocessor support chips, processor example, programmed input/output interrupts, bus signals and interfacing, data communication concepts; Project; design and construction of a practical electronic circuit

Recommended Texts:
1. Horowitz, P. and Hill, W., *The Art of Electronics* (1989) , Cambridge uni.press, 2nd ed

PH 454 Solid State Ionics & Devices (2 credits)
Ionic conductivity and solid electrolytes, point defect notation, type of defects, ionic mobility in solids, theoretical explanation of ionic conductivity, Arrhenius relationship, requirements for high ionic conductivity, types of solid electrolytes, some representative examples, composite electrolytes, polymer electrolytes, glassy electrolytes, ionic conductivity measurement, complex impedance technique, transference number and d.c. polarisation, intercalation compounds, solid state batteries, fuel cells, sensors, electrochromic devices

Recommended Texts:
1. West, A.R., *Solid State Chemistry* (1984), John Wiley & sons
2. Chandra, S., *Superionic Conductors* (1981), North-Holland Publishing company

PH 455 Polymer Physics (2 credits)
History of the development of synthetic polymers; chemical nature of polymers; Classification of polymers: Thermoplastic versus thermoset polymers, amorphous versus crystalline polymers molecular sizes and shapes and ordered structures; Distributions of molar mass and their determination, Bonding and the shapes of molecules, Conformations and chain statistics, The single freely jointed chain more realistic chains, the excluded-volume effect, Chain flexibility and the persistence length, Evidence for ordered structures in solid polymers, Morphology: crystallinity, orientation; Mechanical Properties: strength, modulus, elongation, hardness; Thermal properties: glass transition temperature, heat capacity, thermal conductivity, thermal expansion coefficient Optical properties: light transmission, refractive index; Electrical properties: surface and volume resistivity, dielectric constant, electronic conductivity, ionic conductivity, piezoelectric. Differential scanning calorimetry (DSC) and differential thermal analysis (DTA), Density measurement, Light scattering, X-ray scattering, Infrared and Raman spectroscopy, NMR technique, Optical and electron microscopy. Applications of polymers, processing, environmental issues and recycling.

Recommended Texts:
1. Bower, D.I., *An Introduction to Polymer Physics*, Cambridge Univ. Press
2. R.J. Young & P.A. Lovell, *Introduction to Polymers, 2nd Ed.*, Chapman & Hall, UK (1996)
3. P.C. Painter & M.M. Coleman, *Fundamentals of Polymer Sciences, 2nd Ed.* Technomic Pub. Co. Inc, USA.(1997)
4. J.W. Nicholson, *The Chemistry of Polymers*, Royal Society of Chemistry, UK. 1991

PH 456 Nuclear Magnetic Resonance (NMR) (2 Credits)

***Introduction*:** NMR, NMR Spectroscopy , Units Review ***The Mathematics of NMR*:** Exponential Functions, Trigonometric Functions, Differentials and Integrals, Vectors , Matrices, Coordinate Transformations, Convolutions, Imaginary Numbers, The Fourier Transform, ***Spin Physics*:** Spin, Properties of Spin, Nuclei with Spin, Energy Levels, NMR Transitions, Energy Level Diagrams, Continuous Wave NMR Experiment, Boltzmann Statistics, Spin Packets, T1 Processes, Precession, T2 Processes, Rotating Frame of Reference, Pulsed Magnetic Fields, Spin Relaxation, Spin Exchange, Bloch Equations ***NMR Spectroscopy*:** Chemical Shift, Spin-Spin Coupling, Time Domain NMR Signal, +/- Frequency Convention ***Fourier Transforms*:** Introduction, The + and - Frequency Problem, The Fourier Transform, Phase Correction, Fourier Pairs, The Convolution Theorem, The Digital FT, Sampling Error, The Two-Dimensional FT ***Pulse Sequences*:** Introduction,90-FID,Spin-Echo,Inversion Recovery ***NMR Hardware*:** Hardware Overview, Magnet, Field Lock, Shim Coils, Sample Probe, RF Coils, Gradient Coils, Qadrature Detector, Digital Filtering, Safety ***Practical Considerations*:** Introduction, Sample Preparation, Probe Tuning, Determining a 90^{o} Pulse, Field Shimming, Phase Cycling, 1-D Hydrogen Spectra, Integration, SNR Improvement, Variable Temperature, Troubleshooting, Cryogen Fills ***Carbon-13 NMR*:** Introduction, Decoupling, Population Inversion, NOE, 1-D Spectra ***2-D Techniques*:** Introduction, J-resolved, COSY, Examples ***Advanced Spectroscopic Techniques*:** Introduction, Diffusion, Spin Relaxation Time, Solid State, Microscopy, Solvent Suppression, Field Cycling NMR

Recommended Texts:

1. Principles of Nuclear Magnetic Resonance in One and Two Dimensions, Richard R. Ernst, Oxford University Press, 1990
2. Basic One- and Two-Dimensional NMR Spectroscopy, Horst Friebolin, Wiley-VCH, Weinheim, 2005
3. A Handbook of Nuclear Magnetic Resonance, Ray Freeman, Longman 1997

PH 457 Advanced Nanoscience (2 credits)

(Prerequisites: PH 375)

Photonic Crystals: Theory of Periodic Structures, Dispersing Relationships, Band Structures, Growth, Devices, *Confined Electronic Systems:* Quantum Dots, Plasmon, STM & AFM, *Molecular Electronics:* Wires, Insulators, Diodes, Switches, Measuring Resistance, *Nanoscale Electronics:* Coulomb Blockage, Single Electron Transistors, Nanocapacitors, Quantum Cellular Autamata, *Spintronics:* Spin Transport, Giant Magnetoresistance, Diluted Magnatic Semiconductors, Quantum Computing.

Recommended Text:

1. The Phisics and Chemistry of Nanosolids, Frank Owners and Charles Pool, John Wiley, 2008
2. Fundermentals of Nanoelectronics, George Hanson, Pearson, 2008

PH 481 Advanced Physics Laboratory III (4 credits)

(Prerequisites: PH 381 & PH 382)

PH 486 Nuclear Physics Laboratory (2 credits)

(Prerequisite: PH 436)

An introduction to the devices and techniques most common in nuclear measurements. Topics include the principles of operation of gas-filled and scintillation detectors for charged particle, gamma ray and neutron radiations. Techniques of pulse shaping, counting, and analysis for radiation spectroscopy. Timing and coincidence measurements.

PH 487 Investigation Laboratory (1 credit)

PH 491 Research Project (6 credits)

A student is expected to carry out an independent research project on a topic assigned to him/her under the supervision of a senior faculty member. At the completion of the project the student is expected to write a report and make a presentation.

PH 493 Independent Study (1 credit)

PH 496 Laboratory Teaching course (1 credit)

This teaching course is available for a fourth year Physics Special student selected by the Department of Physics. The course involves laboratory teaching (one laboratory class per week) in an undergraduate laboratory for one semester.