SEMESTER III

M3PHY01-CT09: Atomic and Molecular Physics

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 80 Marks Internal: 20 marks
Lectures: 40hrs Tutorials : 10 hrs
Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

Note: Candidates whose attendance is less than 75% will be awarded zero marks in the Internal

UNIT-I (8L)

General introduction – Atomic orbital, Electromagnetic spectrum, Hydrogen Atom spectrum-I Hydrogen Atom spectrum-II, Pauli's Principle, Spectra of alkali atoms- I, Spectra of alkali atoms- II, Spin orbit interaction, Fine structure in alkali Spectra, Equivalent and non equivalent electrons

UNIT-II (8L)

Normal Zeeman Effect, Anomalous Zeeman Effect, Paschen back effect, Stark Effect, Two electron systems , LS and JJ coupling, determination of nuclear spin and nuclear g factors, transition probabilities and line width, Doppler, natural collision and stark broadening

UNIT-III (8L)

Rotation spectra of diatomic molecules, Rotation spectra of Polyatomic molecules, Techniques and instrumentation, Chemical analysis by Microwave spectroscopy, Diatomic vibrating rotator, The interaction of rotation and vibration, Vibration of poly atomic Molecules, I-R- Spectrometer

UNIT-IV (8L)

Pure rotational Raman Spectra, Vibrational Raman Spectra, Polarization of light and Raman Effect, Structure determination from Raman effect, Structure determination from IR, spectroscopy, Raman Spectrometer, Near I R Raman Spectroscopy, F T Raman Spectroscopy

UNIT-V (8L)

Electronic Spectra of Diatomic molecules, Electronic Spectra of poly atomic molecules, Molecular Photoelectron Spectroscopy, General Introduction – Resonance Spectroscopy, NMR Spectroscopy- I, NMR Spectroscopy- II, ESR Spectroscopy- I, ESR spectroscopy- II

Tutorials (10hrs)

Examples and problems from Reference books will be listed in the Lecture schedule as Tutorials and assignments

Reference Books:

1. G.K. Woodgate, Elementray Atomic Structure, Second Edition Clarendon Press, Oxford.
2. Colin N. Banwell and Elaine M McCash, Fundamentals of Molecular Spectroscopy
3. T.A. Littlefield - Atomic and Molecular Physics.
4. Eistaberg and Rasmic- Quantum Physics of Atoms. Molecules Solids and Nuclear Particles.
5. Ashok Das and A.C. Melfessions. quantum Mechanics ; A Modem Approach (Gordon and Breach Science Publishers).
6. White - Atomic Spectra.
7. Herzberg- Molecular spectra.
8. Charles Kittle- Spectroscopy
9. Gupta & Kumar- Spectroscopy

M3PHY02-CT10: Solid State Physics

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 80 Marks Internal: 20 marks
Lectures: 40hrs Tutorials : 10 hrs
Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

Note: Candidates whose attendance is less than 75% will be awarded zero marks in the Internal

UNIT-I

Crystallinity and Forms of Solids (8hrs):
Crystal classes and systems, periodic array of atoms, fundamental types of lattices, 2d and 3d lattices, index system for crystal planes, simple crystal structures, non ideal crystal structures, elementary ideas of point defects: line defects, planar faults, surface and volume defects, lattice vacancies, interstitials, colour centers, F-centers.
Reciprocal lattice, diffraction of waves by crystals, scattered wave amplitude, structure factor, Brillouin zones.

UNIT-II

Lattice Dynamics(8hrs)
Lattice vibrations, phonons, vibrations of crystals with monoatomic basis, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons. Specific heat of solids, phonon heat capacity, anharmonic crystal interactions, thermal conductivity.

UNIT-III

Electrons in Solids (8hrs):
Free electron theory- Fermi statistics, effect of temperature on the Fermi- Dirac distribution, free electron gas in three dimensions, heat capacity of the electron gas, electron motion in magnetic fields.
Number of orbitals in a band, energy bands in metals, insulators and semiconductors, tight binding approximations.

UNIT-IV

Idea of reduced and periodic zones, construction of Fermi surfaces, electron orbits, hole orbits, open orbits, de Haas van Alfen effect for Fermi surface (no derivation). **(4hrs)**
Superconductivity, Meissner effect, type-I and type-II superconductors, BCS theory of superconductors, Josephson junctions. **(4hrs)**

UNIT-V

Magnetic Phenomena in Solids (8hrs):

Langevin diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, paramagnetism, quantum theory of paramagnetism, Hund's rules.

Ferromagnetic order, magnons, neutron magnetic scattering, Antiferromagnetic order, Ferromagnetic domains, single domain particle.

Tutorials (10 T hrs)

Examples and problems from Reference books will be covered during Tutorials and assignments.

Recommended Book:

1. Introduction to Solid State Physics by Charles Kittel (Seventh or higher Edition).
2. Solid State Physics by A.J. Dekker

M3PHY03-ET01A: Radiation Physics

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 80 Marks Internal: 20 marks
Lectures: 40hrs Tutorials : 10 hrs
Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

Note: Candidates whose attendance is less than 75% will be awarded zero marks in the Internal

UNIT-I

Sources of Radiation (6hrs): Cosmic rays, radioactive sources, accelerators (Brief study of principle of operation & characteristics of radiations of Cockroft Walton, Van de Graff, cyclotron, electron linac, electron synchrotron) Synchrotron radiation: Polarization, coherence and emittance. Neutron Source: Reactors, Neutrons from charged particle and photon induced reactions.
Radiation Protection (2hrs): Units and special parameters, background levels, radiation carcinogesis

UNIT-II

Interaction of Charged Particle with Matter (3hrs): Definition of range, types of charged particle interaction, energy transfer in elastic collisions, Bethe formula, scattering of heavy and light charged particles

Interaction of Photons (5hrs): Attenuation coefficients, classical scattering from single electrons, coherent scattering, Klein –Nishina cross section for Compton scattering (No derivation), Compton scattering from atomic electrons: Effect of electron binding, electron recoil energy, electron momentum distributions from Compton profiles. Photoelectric absorption, characteristic X-rays, Auger electrons, pair production

UNIT-III

Interaction with Neutrons (8hrs): Neutron interactions, Neutron fields in non-multiplying media: Definition of flux, current density, collision dynamics, distribution of energy and angle of scatter, Mean scatter angle and energy loss in single collision, extension to multiple collision, slowing down in hydrogen, neutron diffusion, moderation and diffusion.

UNIT-IV

Nuclear Detectors (4hrs): Gas detectors, Scintillation detector, Semiconductor detectors

Microdosimetry and Radiation Effects (4hrs): Experimental determinations of microdosimetric spectra, practical considerations, primary radiation effects, track structure, radiation effects in condensed systems, radiolysis of water, dosimeter

UNIT-V

Dosimetry (4hrs): Charged particle equilibrium, photon interaction coefficients, relation between exposure, kerma and absorbed spectra, measurement of exposure, practical aspects of ionization chamber dosimetry, calorimetry, standardization for low and medium energy X-rays, high energy photons, electrons, chemical dosimeters, TLD, solid state and film dosimeters

Brief discussion of radiotherapy using photons, electrons and heavy particles **(2hrs)**
Brief introduction to radiation imaging techniques (Diagnostic radiology, tomography, MRI, Nuclear Medicine) **(2hrs)**

In addition to the above 10 hrs tutorials, assignments will be given by the teacher concerned.

Reference books:

1. A Primer in Applied Radiation Physics by F.A. Smith (World Scientific).
2. Nuclear Radiation Physics by R.E. Lapp and H.L. Andrews (Prentice-Hall, New Jersey, 1972).

Course M3PHY03-ET01B : Plasma Physics

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 80 Marks　　Internal: 20 marks

Lectures: 40hrs　　Tutorials: 10hrs

Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

UNIT-I

Charged particle motion and drifts, Guiding centre motion of a charges particle. Motion in (i) uniform electric and magnetic field (i) gravitational and magnetic fields. Motion in non-uniform magnetic field (i) grad B perpendicular to B, grad B drift and curvature drift (ii) grade B parallel to B and principle of magnetic mirror. Motion in non-uniform electric field for small Larmour radius.(8L)

UNIT-II

Time varying electric field and polarization drift. Time varying magnetic field adiabatic invariance of magnetic moment(2L)

Plasma fluid equations fluid equations; Conventive, Two fluid and single fluid equations. Fluid drifts perpendicular to B diamagnetic drift. Diffusion and Resistivity : Collision and diffusion parameters. Decay of a plasma by diffusion, ambipolar diffusion

UNIT-III

Diffusion across magnetic field. Collision in fully ionized plasma. Plasma resistivity Diffusion in fully ionized plasmas. Solution of Diffusion equation.(3L)

Hydromagnetic equilibrium. Concept of magnetic pressure. Equilibrium of a cylindrical pinch. The Benner pinch. Diffusion of magnetic field into a plasma (5L)

UNIT-IV

Classification instabilities. Two stream instability. The gravitational instability Resistive drift waves.(3L)

Understanding the Sun: Solar plasma magneto hydrodynamics, solar magnetism, Chromospheres and corona, Solar wind and heliosphere, solar eruptions. Solar vibrations (GONG) sunspots and sunspots cycle.

UNIT-V

Solar plasma electrodynamics for solar luminosity, opacity, temperature, pressure, mass, radius and gases. The Sun's continuous and absorption line spectrum, solar energy transport, photosphere, chromospheres corona and solar winds. Solar interior, nucleus transformation and fusion reactions, solar neutrino experiments. (6L)

Basic of nebular models and the formation of the planets, Asteroid, Comets, Meteors. (2L)

Tutorials (10 hrs)

Examples and problems from Reference books will be listed in the Lecture schedule as Tutorials and assignments

References :

1. F.F. Chen : An Introduction to Plasma Physics (Plenum Press) 1977.
2. R.C. Davidson : Methods in Non-linear Plasma Theory (Academy Press) 1972.
3. W.B. Kunkel : Plasma Physics in Theory and Application (Mc Graw Hill)1966.
4. J.A. Bittencoms : Fundamentals of Plasma Physics (Pergamons Press. 1986.

Course M3PHY03-ET01C: Theoretical Methods in Condensed Matter Physics

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 75 Marks Internal: 25 marks

Lectures: 40hrs Tutorials: 10hrs

Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

UNIT-I

Electronic Structure: Single electron Model: Basic Hamlitonian, Densities of States, Statistical mechanics of non interacting electrons, sommerfield expansion :specific heat of non interacting electrons at low temperatures

Schrodinger equation and Symmetry: Translation Symmetry-Bloch's theorem, vanhove singularities, Fourier analysis of Bloch's theorem, Kronney penney model

UNIT-II

Rotational Symmetry: classes and characters, consequences of point group symmetries for Schrodingers equation.

Nearly free and tight bound electrons: Nearly free electrons- Degenerate perturbation theory, Brillouine zones-Nearly free electron Fermi surfaces.

UNIT-III

Tight bound electrons:Wannier functions and tight binding model.

Electron Electron Interaction: Hartree and Hartree-Fock equations : Hartree –fock equations, numerical implementation.

UNIT-IV

Density fuctional theory: Thomas Fermi theory and Kohn-shyam equations.

Calculations of Band Structure: Numerical methods: Psuedopotentials and orthogonal Plane wave

UNIT-V

,LCAO, Plane waves, LAPW, LMTO, Brief survey of Periodic table

Tutorials (10 Hrs)

Examples and problems from Reference books will be listed in the Lecture schedule as Tutorials and assignments

Reference Book:

1. Condensed Matter Physics, Michael P Marder, Wiley Interscience, 2000
1. Solid State Phyics, Ashcroft & Mermin

M3PHY04-ET02A : INDUSTRIAL ELECTRONICS

UNIT I

POWER DEVICES

Power diode – Power transistor – Power MOSFET – SCR – TRIAC – GTO – IGBT – MCT –Protection of power devices.

UNIT II

CONVERTERS

Introduction to half wave, full wave and bridge rectifiers – Single phase and three phase – Half controlled and fully controlled converters – Dual converters – Introduction to cyclo converters and ac controllers.

UNIT III

INVERTER AND CHOPPER

Voltage, current and load commutation – Voltage Source Inverter (VSI) – Series and Parallel inverter – Bridge inverters – Single and three phase – Voltage control using PWM – Current Source Inverter (CSI) – Choppers – Step up and step down choppers – Chopper classification – Class A,B, C, D, E – AC choppers.

UNIT IV

DC AND AC DRIVES

Steady state characteristic of dc motors – Control of DC motor using converters and choppers –Regenerative and dynamic braking – Closed loop control scheme – Speed-torque characteristic of induction motor – Static stator voltage control – V/f control – Static rotor resistance control – Slip power recovery scheme – Self control of synchronous motor.

UNIT V

OTHER APPLICATIONS

Electronic timers – Digital counters – Voltage regulators – Online and offline ups – Switched mode power supply – Principle and application of induction and dielectric heating.

TEXT BOOK:

1. G. K. Mithal, “Industrial Electronics”, Khanna Publishers, Delhi, 2000.

REFERENCES

1. M. H. Rashid, “power Electronics Circuits, Devices and Application”, PHI, 3rd edition, 2004.
2. G. M. Chute and R. D. Chute, “Electronics in Industry”, McGraw Hill Ltd, Tokyo, 1995.
3. F. D. Petruzulla, “Industrial Electronics”, McGraw Hill, Singapore, 1996.

Course M3PHY04-ET02B : Data and Computer Communications

UNIT-I

Protocol Architecture : Overview: Communication model, Communication Tasks, Data Communication Networking: WAN, LAN,Wireless Networks. Basics of Network Software: Protocol and protocol architecture, Protocol functions, Design Issues for the layers, interfaces &Services, Connection oriented and connectionless services, service primitives, relationship of services to protocols , ISO REF Models, TCP/IP Model.

Data Communications: Data Transmission: Concepts of Frequency,Spectrum, bandwidth, Electromagnetic spectrum and frequencies for data communication, Fourier analysis , Data and signal, Transmission impairments, channel capacity, Nyquist bandwidth, Shannon capacity formula ,decibels and signal strength, Transmission media:Coaxial, twisted pair, Comparative study of Categories of cables, Coaxial, Optical Fibers, Wireless transmission: TerrestialMicrowave, satellite,Broadcast Radio,Infrared,.

UNIT-II

Data Encoding: BCA (NRZ,Bipolar AMI, B8ZS, HDB3,ASK,FSK,PSK,PCM,AM,FM,PM), Spread Spectrum. Asynchrous and Synchronous transmission, Full and Half duplex, Interfacing, Functional and Procedural aspects of V.24,

Data Link Control: Flow control: Stop and Wait, Sliding window, Error detection: Parity Check,CRC. Error control: Stop and Wait ARQ, Go back-N ARQ, Selective-Reject ARQ, Brief idea of HDLC and other Data Link control protocols

UNIT-III

Circuit Switching: Simple switching Network, Circuit Switching Networks, Circuit Switching Concepts: Space Division switching, Time Division Multiplexing, Routing in circuit switching Networks, Contrl Signalling, Inchannel & common channel signaling, Brief idea of SS7. Packet Switching: Packet switching principles, Routing,X.25

UNIT-IV

LAN Technology: LAN architecture, IEEE 802 standards, Ethernet (CSMA/CD): Medium Access Control, 10, 100, Gigabit Ethernet. Brief survey of other LAN systems (Token ring,FDDI,ATM, Fiber channel). Wireless LANS, Bridges, Latest trends in LAN technologies

LAN Devices: Study of specifications of L2 and L3 switches, Structured cabling, Passive components.

UNIT-V

Principles of Internetworking, connection less Internetworking, IP, IPv6, IP multicasting. Routing protocols, TCP, UDP, SNMP,SMTP and MIME, HTTP.

Recommended Books :

1. William Stallings: Data & Communications,Sixth Edition

2. A. S. Tanenbaum : Computer Networks

Course M3PHY04-ET02C : Programming using JAVA

UNIT-I

Introduction to Java: Bytecode, features of Java, data types, variables and arrays, operators, control statements.

Objects & Classes: Object Oriented Programming, defining classes, static fields and methods, object construction

UNIT-II

Inheritance: Basics, using super, method overriding, using abstract classes, using final with inheritance.

Packages and Interfaces: Defining a package, importing package, defining an interface, implementing and applying interfaces.

UNIT-III

Exception Handling: Fundamentals, exception types, using try and cache.

Multithreaded Programming: Creating a single and multiple threads, thread priorities, synchronization.

UNIT-IV

Applets: Applets basics, applets architecture, applets skeleton, the html applet tag, passing parameters in applets.

Event Handling: Event classes and event listener interfaces.

UNIT-V:

Graphic Programming Introduction to swings.

Recommended Books :

1. P. Naughton and H. Schildt: The complete reference to Java, Tata Mc-Graw Hill.
2. Deitel and Dietel: How to program in Java

M3PHY04-ET02D: Semiconductor Physics and Devices

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External: 80 Marks Internal: 20 marks
Lectures: 40hrs Tutorials: 10hrs
Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

UNIT-I: Semiconductor in Equilibrium and Carrier Transport Phenomena

Chemical equilibrium and mass-action law, allowed and forbidden bands, electrical conduction in solids, density of state function and its extension to semiconductors, Statistical mechanics, charge carriers in semiconductors, dopant and energy levels, extrinsic semiconductors, statistics of donors and acceptors, charge neutrality and position of Fermi levels, carrier drift, carrier diffusion and graded impurity distribution.

UNIT-II: Excess Carriers in Semiconductors and the p-n Junction

Carrier generation and recombination; characteristics of excess carriers, Ambipolar transport and quasi-Fermi energy levels, Excess carrier lifetime: Shockley-Read-Hall theory of recombination

Surface effects, basic structure of p-n junction and p-n junction under zero bias; Built-in potential barrier, electric field and space charge width, p-n junction under forward and reverse bias, junction capacitance, one-sided p-n junction and non-uniformity doped junction, p-n junction current, small-signal model of the p-n junction, diode carrier equation and junction breakdown, charge storage and diode transients, the Schottky barrier diode: metal-semiconductor junction, semiconductor-semiconductor junction, metal-semiconductor ohmic contacts and hetero-junctions, electrochemical junction, junction in organic materials.

UNIT-III: Physics of Semiconductor Devices

The Physics of Bipolar junction transistor (BJT), Field effect transistor (FET), Photo-detectors, Light emitting diodes (LEDs), Laser diodes, Power semiconductors devices, Integrated circuits, High-frequency, high-power and nano-electronic devices, Semiconductor process technology, MBE and MOCVD.

UNIT-IV: Physics of Solar Cells

Photovoltaic cells and power generation, characteristics of photovoltaic cells, detailed balance, photo-current, device current, limiting efficiency, effect of band gap and spectrum on efficiency; depletion approximation and calculation of carrier and carrier densities, general solution for J (V), p-n junction in dark and under illumination, effects of parasitic resistance, irradiation, temperature on p-n junction characteristics, lattice matching in epitaxial growth, Epitaxial growth, vapor phase epitaxy; growth of single-crystal ingots, wafer and doping.

UNIT-V: Solar Cell Devices

Monocrystalline solar cells: principle and cell design, materials and design issues, Silicon material properties and Silicon solar cell designs; III-V semiconductor material properties and GaAs solar cell design, thin film solar cells: thin film photovoltaic materials; amorphous Silicon and amorphous Silicon solar cell design, defects in polycrystalline thin film materials, $CuInSe_2$, CdTe and Silicon thin film solar cells, organic, dye sensitized and perovskite solar cells, Managing light: Photon flux, concentration, effect of concentration on device physics, light confinement, photon recycling, Strategies for high-efficiency.

Reference books:

1. Donald A. Neamen and Dhrubes Biswas; Semiconductor Physics and Devices, 4th edition, McGraw Hill, 2003.
2. S.M. Sze, Semiconductor device Physics and Technology, John Wiley and Sons, 2002.
3. Ben. G. Streetman and Sanjay K. Banerjee, Solid Sate Electronics Devices, 7th edition, PHI, 2014.
4. Jenny Nelson; The Physics of Solar Cells, 1st edition, Imperial College press, 2003.
5. L. Fraas and L. Partain, Solar Cells and their applications, John Wiley and Sons, 2010.
6. T. Markvart and L. Castaner, Solar Cells: Materials, Manufacture and Operations, Elsevier, 2005.
7. N.D. Gupta and A.D. Gupta, Semiconductor Devices Modeling and Technology, PHI, 2013.

M3PHY05-CP05: Data Analysis Techniques in Experimental Physics

Computer based data analysis Techniques will be offered. Details will be available on course web site

M3PHY06-EP0XX : Practical-I (Elective)

M3PHY06-EP01A : Radiation Physics Lab

Experiments based on Monte Carlo simulations for multiple scattering of photons in in-vivo tissues, skeleton bones, water, etc., Computation of photon cross-sections and mass attenuation coefficients of various biological tissues and tissue-equivalent materials using XCOM program of J.H. Hubbel, Use of HPGe detector in analysis of γ-ray spectra.

References:

1. Radiation Detection and Measurement by G.F. Knoll (John Wiley & Sons, New York).
2. J. Felsteiner et al. Philos. Mag. **30**, 537 (1974).
3. XCOM code by J. H. Hubbel, University of California, USA.

M3PHY06-EP01B : Plasma Physics

M3PHY06-EP01C:Theoretical methods in Condensed Matter Physics

M3PHY06-EP02C: Programming using JAVA

M3PHY06-EP02D: Semiconductor Physics and Devices

M3PHY06-EP01P: Project Work

Students are allowed to offer a Project work under supervision of a faculty member. The project will be evaluated centrally at the University Department.