GUJARAT UNIVERSITY

M. Sc. (Physics) Semester - II
(Effective from: 2016-2017)

Course	Name of the Course	Lect. Hrs. / Week	Internal Marks	External Marks	Total Marks	Course Credits
PHY-407	Quantum Mechanics - II and Mathematical Physics - II	4	30	70	100	4
PHY-408	Classical Mechanics - II, Electrodynamics and Plasma Physics	4	30	70	100	4
PHY-409	Solid State Properties and Physics of Semiconductor	4	30	70	100	4
PHY-410	Remote Sensing and Electronics - II	4	30	70	100	4
PHY-411PR PHY-412PR	Practicals Practicals	12	60	140	200	8
TOTAL		**28**	**180**	**420**	**600**	**24**

GUJARAT UNIVERSITY

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PHY - 407 : Quantum Mechanics - II and Mathematical Physics - II

The study of Quantum mechanics and mathematical physics help to understand almost all the modern branches of physics. Both are consider to e language of physics.

UNIT - I: Quantum dynamics, Atoms and Molecules

The equations of motion, The Schödinger picture, The Heisenberg picture, Indistinguishable particles, Pauli principle, Inclusion of spin, Spin functions for two electrons, Spin functions for three electrons, The Helium Atom, Central field approximation, Thomas - Fermi Model of the atom, Hartree equation, Hartree Fock equations.

UNIT - II: Einstein's Quantum Theory of Radiation

Time dependent perturbation theory, Electric dipole interaction, Quantum electrodynamics, Creation and annihilation operators, Fock states, Quantization of field, Zero point energy, Cohrent state, Description of the electromagnetic field, Interaction of radiation with matter.

UNIT - III: Complex Variable

Introduction, Analytical Function, Theorems, Illustrative examples, Contour Integral Theorem, Cauchy's Integral Formula Theorem, Illustrative examples, Laurent Series Theorem, Method of finding residues. The Residue Theorem, Evaluation of Definite, Integrals by use of the residue theorem, Examples, Argument principle Example, Additional illustrative examples, The point at infinity, residue at infinity, Mapping Examples, Conformal mapping, Some Application of conformal Mapping examples, Additional illustrative examples.

UNIT-IV: Integral equations and Green's functions

Introduction, Conversion of differential equation into an integral equation, Linear Harmonic oscillator, Liouville - Neumann series, Separation methods, Examples

Non homogeneous boundary value problems and Green's functions, Green's functions for one - dimensional problems, Eigen function expansion of Green's function, Fourier transform method of constructing the Green's function, Green's functions in higher dimensions

Reference books:

1. Quantum Mechanics, V. K. Thankappen, Wiely eastern limited.
2. Quantum Mechanics, G. Aruldhas Prentice - Hall of India Private Limited.
3. Lasers and non - linear optics, B. B. Laud, New Age International Ltd.
4. Mathematical methods in the physical sciences, M.L Boas., JohnWilley, 1966
5. Mathematical Physics, P. K. Chattopadhyaya, Wiley Eastern Ltd.
6. Quantum Mechanics, L. I. Schiff, McGraw - Hill
7. Quantum Mechanics : Theory and applications A. Ghatak and S. Lokanathan, Macmillan India Limited.
8. Mathematical methods for Physicists, G. Arfken, Academic Press, 1970
9. Mathematical Physics, S. Satyaprakash, Sultan Chand & Sons, 1990

GUJARAT UNIVERSITY

M. Sc. (Physics) Semester - II
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PHY – 408 : Classical Mechanics – II, Electrodynamics and Plasma Physics

The study of electrodynamics helps in understanding the natural processes occurs in solids, liquids and gases. The modifications in the electric and magnetic field in al substances can be studied with the knowledge of the subject. The study of plasma physics helps to understand the instability and the fission problem.

UNIT - I: Non Linear Oscillations and Chaos

Introduction, Singular Points of Trajectories, Nonlinear Oscillations, Volter's Problem, Limit cycle, Chaos, Logistic Map, Poincare System, Strange attractors

UNIT - II: Relativistic electrodynamics and classical field theory

Relativistic Mechanics, Proper time and proper velocity, Relativistic energy and momentum, Relativistic kinematics, Relativistic dynamics, Relativistic electro dynamics, How field transform, The field tensor, Electro dynamics in tensor notation, Relativistic potentials.

The transition from a discrete to a continuous system., The Lagrangian formulation for continuous system, Sound vibrations in gases as an example of Lagrangian formulation, The Hamiltonian formulation for continuous system, Description of fields by variational principles.

UNIT - III: Scattering and Dispersion

Scattering of radiation by a free charge, Scattering of radiation by a bound charge, Radiation damping, Dispersion in dilute gases, Dispersion in liquids and solids. Frequency dependence of ϵ, μ, σ. Dispersion in non conductors, Free electrons in conductors and Plasma, Illustrative Examples.

UNIT - IV: Plasma Physics

The moment equations, Derivation of the moment equations, Magnetohydrodynamic OR MHD, One fluid model, Two fluid model, Illustrative Examples.

Collisions, Liouville equation, The system of B.B.G.K.Y. Equations, The B-V equation with self consistent field, Illustrative Examples.

Controlled thermonuclear reaction, Lawson criterion, The Coulomb barrier, Heating and confinement of the plasma, Radiation loss of energy, Instability problem, Magnetohydrodynamic conversion of energy, Plasma propulsion, Other plasma devices, Illustrative Examples.

Reference books:

1. Classical Mechanics, V. B. Bhatia, Narosa Publishing house.
2. Classical Mechanics (2^{nd} Edition), Herbert Goldstein, Addison - Wesley Publishing Co.
3. Introduction to Electrodynamics (2^{nd} & 3^{rd} Edition) J. Griffiths, Prentice Hall India Ltd.
4. Electromagnetics (2^{nd} Edition), B. B. Laud, Wiley Eastern,
5. Elements of Plasma Physics, S. N. Goswami, New Central book Agency Pvt. Ltd, Calcutta
6. Introduction to Plasma Physics, Chen F. F., Plenum Press
7. Classical Mechanics, G. Aruldhas PHI Pvt. Ltd.
8. Classical Mechanics, J. C. Upadhyaya Himalaya Publishing House.
9. Classical Mechanics, S. N. Biswas Books and allied (P.) Ltd.
10. Classical Mechanics (3^{rd} ed.), Goldstern, Poole and Safko, Pearson Education.

GUJARAT UNIVERSITY

M. Sc. (Physics) Semester - II
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PHY - 409 : Solid State Properties and Physics of Semiconductor

This paper is introduced as a core course in majority of universities. Proposed syllabus includes several fundamental and advanced topics of semiconductor physics. The syllabus is complementary to solid state physics and condensed matter physics.

UNIT - I: Magnetism

Diamagnetism, Paramagnetism, Electron Spin Resonance, Nuclear Magnetic Resonance, Spin Relaxation, Weiss theory of Ferro magnetism, the exchange interaction, The Heisenberg model, Ferromagnetic domains, The Bloch wall, Origin of domains, Neel model of Antiferromagnetism, Neel model of Ferrimagnetism, Spin waves, Magnons in Ferromagnets, The Bloch $T^{3/2}$ law, Magnons in Antiferromagnets.

UNIT - II: Superconductivity

Introduction, Meissner effect, Heat Capacity, Energy gap, Isotop effect, Thermodynamics of the superconducting transition, London equation, Coherence Length, BCS theory of superconductivity, BCS ground state, Flux quantization in a superconducting ring, Type - I and Type -II superconductors, Vortex state, Single particle tunneling, Josephson superconductor tunnelin, DC Josephson effect, AC Josephson effect, Macroscopic quantum interference, Introduction to High Tc Superconductors

UNIT – III: Energy Bands and carrier concentration in Thermal Equilibrium

Energy Bands; Energy levels of isolated atoms, Energy momentum Diagram, Direct and Indirect band gap semiconductors; band diagrams of metals, semiconductors and insulators, Intrinsic carrier concentration, Concept of Fermi factor, Extrinsic semiconductors : Donors and Acceptors, Nondegenerate and Degenerate semiconductors, Carrier Drift : Mobility and its relation with resistivity and conductivity, The Hall effect.

UNIT – IV: *p-n* Junction

Band Diagram of *p-n* junction in thermal equilibrium; Equilibrium Fermi levels; Space Charge; Depletion region, Abrupt junction; Widths of the depletion region in abrupt junction; Depletion capacitance; Capacitance-voltage characteristics; Current voltage characteristics; Ideal diode equation.

Reference books:

1. Introduction to Solid State Physics (7^{th} edition), C. Kittle, Wiley Eastern Limited, New Delhi
2. Elements of Solid State Physics, J. P. Srivastava, PHI, India.
3. Intermediate Quantum Theory of Crystalline Solids, A. O. E. animalu, Printice-Hall of India Pvt. Ltd.
4. Semiconductor Devices : Physics and Technology (2^{nd} Edition) by S.M. Sze, Wiely (India)
5. Transistors, Denis Le Croissette, Prentice Hall of India Pub. 1965.
6. Physics of Semiconductor Devices (4_{th} Edition), S. M. Sze and Kwok. K. Ng., John Wiely & Co. (India)
7. Semiconductor Physics and Devices: Basic Principle (3_{rd} Edition), Donald Neauman, Tata McGraw Hill.
8. Solid State Electronic Devices (6_{th} Edition), Ben G. Streetman and S. Banerjee, PHI
9. Physics of Semiconductor Devices, Michael Shur, PHI Learning.

GUJARAT UNIVERSITY

M. Sc. (Physics) Semester - II
(Effective from: 2016-2017)

PHY - 410 : Remote Sensing and Electronics - II

(i) To introduce basic concepts of remote sensing in visible, IR and microwave bands, various types of platforms and sensors used for remote sensing, and different interpolation techniques. (ii) To understand the construction and working principle of JFETs and MOSFETs and to use them as circuit elements. (iii) To give an overall view of different digital IC logic families with emphases to TTL and CMOS ICs.

UNIT – I: Remote Sensing principles, platforms and sensors

Remote Sensing principles: Electromagnetic remote sensing process, Radiation laws, Atmospheric interaction with electromagnetic radiation, Interaction with earth surface and spectral signatures

Microwave remote sensing: The Radar principle, Factors affecting microwave measurements, Side-looking airborne radar systems (SALR), Synthetic aperture radar (SAR), Interaction between microwaves and earth surface, Geometrical characteristics

Remote Sensing platforms and Sensor: Satellite system parameters – instrumental parameters, viewing parameters, Sensor parameters – spatial resolution, spectral resolution, radiometric resolution, Imaging sensor systems- multispectral, thermal and microwave imaging, Earth Resource and meteorological satellites

UNIT – II: Image interpretation

Visual image interpretation: Basic elements of image interpretation, Interpretation of aerial photo and satellite imagery, Application of aerial interpretation

Digital image processing: Basic character of digital image, Preprocessing – geometric correction, radiometric correction, atmospheric correction, Image enhancement techniques – contrast enhancement, Spatial filtering techniques – different filters, filtering for edge enhancement, Image transformation – NDVI transformation, PCA transformation, Image classification – supervised and unsupervised classification,

UNIT – III: Field Effect transistors & Optoelectronic Devices

Field Effect transistors**:** JFET: Introduction, Characteristic Parameters of FET, Effect of Temperature on FET Parameters, FET Amplifiers: Common Drain Amplifier, Common Gate Amplifier, MOSFET: Depletion MOSFET, Enhancement MOSFET, Differences between JFET and MOSFET, Handling precaution for MOSFET

Optoelectronic Devices:

Sources: LED: Introduction, Radiative transitions, Emission spectra, Methods of excitations, LED-Structures; Materials for choice, Definition of efficiencies, Semiconductor Laser: Semiconductor laser structures & Materials, Advantages laser over Optical sources

Detectors: Introduction, Photoconductor, Photodiodes, p-i-n & p-n photodiodes, Avalanche photodiode, Phototransistor, Photo voltaic effect and solar cells

UNIT – IV: Digital Integrated Circuits

Introduction, Level of Integration, Digital IC Families, TTL Logic Family**:** Introduction , NAND Gate with Totem-pole Output, Types of TTL, TTL parameters: floating inputs, worst-case input/output voltages, profile and windows, compactibility, sourcing and sinking, noise immunity, standard loading, loading rules. Three state TTL Devices.

MOS Logic Family: Introduction, MOS Inverters, NMOS - NAND & NOR Gates. CMOS Logic Family : NAND & NOR Gates, Power Dissipation, CMOS characteristics: Floating inputs,

Compatibility, Sourcing & Sinking, TTL to CMOS and CMOS to TTL interface, Comparison of Various Logic Families

Reference books:

1. Fundamentals of remote sensing, George Joseph, University press, 2nd edition
2. Remote sensing and Geographical Information systems, Anji Reddy, B.S. Publications, (3rd edition), 2006.
3. Panda B.C., Remote Sensing – principles and applications, Viva Books, 2005
4. Lillesand T.M. and Kiefer R.W., Remote sensing and image interpretation, John Wiley, 4th edition, 2002
5. Campbell J.B., Introduction to remote sensing, Taylor and Francis, 1996
6. Sabins F.F., Remote Sensing, Principles and Interpolation, W.H. Freeman and Co.
7. Jenson J.R., Remote sensing environment: An earth resource perspective, PHI, 2000.
8. Electronic Devices and Circuits: An Introduction, Allen Motershead , PHI
9. Physics of semiconductor devices: S.M. SZE and Kwok K.Ng, 3rd edition, Wiley
10. Optoelectronic Devices and Circuits: A.K. Ganguly, (NAROSA)
11. Digital Principles and Applications, Albert Paul Malvino, Donald P.Leach & Goutam Saha, TMH, 7th Edition
12. Digital Circuits and Systems, C.B Agrawal, & M.K Garg., Umesh Publications

GUJARAT UNIVERSITY

M. Sc. (Physics) Semester - II
(Effective from: 2016-2017)

PHY – 411PR and PHY – 412PR: Practicals

1. Hall mobility and Hall angle
2. Schmitt trigger
3. SCR Characteristic
4. Absorption coefficient of Beta particles of Aluminum
5. Numerical Solution of a Polynomial
6. Resistivity of a semiconductor by four probe method
7. OPAMP as Adder and Substractor
8. OPAMP as Integrator and differentiator
9. Calculation of Empty Lattice Energy Bands
10. C-programming
11. Study of Frequency response curve of FET amplifier
12. Characteristics of Optoelectronics devices
13. Curie Temperature of a given material
14. Wavelength of a LASER source
15. Characteristics of a MOSEFET
16. Study of bending loss of an optical Fiber

15% of new experiments can be introduce AND / OR replace as per the need, with the permission of the Chairman of the Board of Studies.