मोहनलाल सुखाड़िया विश्वविद्यालय, उदयपुर

MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR

Curriculum Framework, General Rules and Syllabus of Physics

for

Two -Year Postgraduate (M.Sc.) Program in Physics

(Program Code: PG410XX)

As per the Choice Based Credit System (CBCS)

Designed in accordance with Learning Outcomes-Based Curriculum Framework (LOCF) of National Education Policy (NEP-2020)

The DCC and DSE/GEC courses of M.Sc. Physics of IV Semester for Academic Year 2023-2025

(Effective from Academic Year 2024-25)

General Provisions and Rules

1. **Duration of the Course**
   The M.Sc. Physics program will be of four semesters duration under Choice based Credit system as per New Education Policy-2020, which will be conducted in two years.

2. **Eligibility**:
   Candidates seeking admission to the first semester of M.Sc. (CBCS) Physics must have a B.Sc. degree with Physics as one of the optional subjects or as an honor's subject (Level 5.5 or equivalent) with minimum 48% marks from a UGC recognized University.

3. **Admissions**:
   Admissions to the first semester of M.Sc. (Physics) will be made as per admission rules for M.Sc. (CBCS) as prescribed in information bulletin.

4. **Medium of Instruction**
   The medium of instruction and examination shall be English.

5. **No. of Seats**
   Total number of seats: As per information bulletin

6. **Curriculum and Syllabi**
   M.Sc. (Physics) program is of two years (four semesters) as prescribed in course structure and framework approved by the academic council held on June 26, 2023. Course structure is prescribed in Table-I and syllabi are given in Table-II. The program will be governed by the Common Rules and Regulations of Master's degree program under CBCS following NEP-2020 approved by the Academic Council of the University.

7. **Examinations of Practical Papers**
   End of semester (EoS) practical examination will be conducted by a board of examiners (one internal and one external). Internal examination (three hours test) will be conducted at the departmental level.

8. **Internal Examinations of Theory Papers**
   Internal examination (one hour test) of theory papers will be conducted at the departmental level.

9. **Exit and Lateral Entry Policy**
   Exit and Lateral Entry Policy shall be as prescribed in course structure and framework approved by the academic council held on June 26, 2023.

10. **Choice of the DSE Courses**
    The DSE courses listed in the program shall be offered depending upon the resources available in the department. A minimum ten students should opt for such a DSE paper.

Table-I: Course structure

Level	Sem	Course Type	Course Code	Course Title	Delivery Type			Total Hours	Credit	Internal Assessment	EoS Exam	M.M.	Remarks
					L	T	P						
8	I	DCC	PHY8000T	Mathematical Methods in Physics	L	T	-	60	4	20	80	100	
			PHY8001T	Classical Mechanics	L	T	-	60	4	20	80	100	
			PHY8002T	Quantum Mechanics-I	L	T	-	60	4	20	80	100	
			PHY8003T	Electronics	L	T	-	60	4	20	80	100	
			PHY8004P	General Physics Lab	-	-	P	120	4	20	80	100	
			PHY8005P	Electronics Lab	-	-	P	120	4	20	80	100	
	II	DCC	PHY8006T	Computational Methods in Physics	L	T	-	60	4	20	80	100	
			PHY8007T	Electrodynamics	L	T	-	60	4	20	80	100	
			PHY8008T	Quantum Mechanics-II	L	T	-	60	4	20	80	100	
			PHY8009P	Electronics Project and Microprocessor Lab	-	-	P	120	4	20	80	100	
			PHY8010P	Computational Physics Lab	-	-	P	120	4	20	80	100	
		DSE	PHY8100T PHY8101T PHY8102T PHY8103T PHY8104T	Statistical Physics Ionospheric Physics Astronomy and Astrophysics Atmospheric Physics	L	T	-	60	4	20	80	100	
9	III	DCC	PHY9011T	Atomic and Molecular Physics	L	T	-	60	4	20	80	100	
			PHY9012T	Solid State Physics	L	T		60	4	20	80	100	
		DSE	PHY9105T PHY9106T PHY9107T PHY9108T PHY9109T	Semiconductor Physics and Devices Fundamentals of Nanoscience Industrial Electronics Condensed Matter Physics	L	T	-	60	4	20	80	100	
			PHY9110P PHY9111P PHY9112P PHY9113P PHY9114P	Semiconductor Physics Lab Nanoscience Lab Advanced Electronics Lab Data Analysis Techniques in Experimental Physics	-	-	P	120	4	20	80	100	

		GEC	PHY9115T	Radiation Physics	L	T	-	60	4	20	80	100	
			PHY9116T PHY9117T PHY9118T PHY9119T	Fundamental Quantum Chemistry General Theory of Relativity Biophysics Elements of Quantum Computing									
			PHY9120P PHY9121P PHY9122P PHY9123P PHY9124P	Radiation Physics Lab Materials Characterization Lab	-	-	P	120	4	20	80	100	
	IV	DCC	PHY9013T	Nuclear and Particle Physics	L	T	-	60	4	20	80	100	
		DSE	PHY9125T PHY9126T PHY9127T PHY9128T PHY9129T	Experimental Techniques in Physics Plasma Physics High Energy Physics Solar Physics	L	T	-	60	4	20	80	100	
		DSE	PHY9130T PHY9131T PHY9132T PHY9133T PHY9134T	Materials Science Quantum Theory of Solids Quantum Field Theory Laser and Spectroscopy	L	T	-	60	4	20	80	100	
		DSE	PHY9135T PHY9136T PHY9137T PHY9138T PHY9139T	Microwave Electronics Fiber Optics and Communication Non-Linear Physics Nanoelectronics	L	T	-	60	4	20	80	100	
		DSE	PHY9140P PHY9141P PHY9142P PHY9143P PHY9144P	Modern Physics Lab Materials Synthesis Lab	-	-	P	120	4	20	80	100	
		DSE	PHY9145P PHY9146P PHY9147P PHY9148P PHY9149P	Microwave Electronics Lab Simulations Lab	-	-	P	120	4	20	80	100	

Table-II: Course Contents

M.Sc. IV Sem. (Physics)

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9013T
Title of the Course	Nuclear and Particle Physics
Qualification Level of the Course	NHEQF Level 6 . 5
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	B.Sc. or advanced level courses of Physics or Mathematics
Co-requisites	None
Objectives of the course	*To strengthen concepts of Nuclear and Particle Physics which are basic building block of the research associated to societal aspects.* *To establish synergy between the undergraduate curriculum and thrust research areas catering present need of the society.* *To cover curriculum aspects to all the competitive examinations associated to civil services and research institutions entrance.* *To frame the curriculum in equivalence with the top academic institutions across the globe.* *To ensure contribution of the deliverables in main stream of development of the society, nation and world.*
Learning outcomes	• The target students stuff would be trained for curriculum associated to the Nuclear and Particle Physics. • Synergy would be established between the bridging curricula covered by the associated students stuff. • The associated student stuff would compete in all the examinations associated to civil services and research institutions entrance. • The student stuff would cover curriculum in equivalence with all the top institutions across the globe. • The associated student stuff would contribute in main stream of development of the society, nation and world.
Syllabus	

UNIT-I	**Properties of stable nuclei:** Nuclear Size; Different type of radii and brief discussion of methods to determine radii, spin and magnetic moment of nuclei. Quadrupole moment of nuclei **(4L+2T).** **Nuclear Force and Two body problem:** Ground state of deuteron: Ground state wave function, Nucleon-Nucleon scattering: Qualitative discussion of n-p and p-p scattering cross section **(4L+2T).**
UNIT -II	Nature of nuclear force, form of nucleon-nucleon potential. Charge-independence and charge-symmetry of nuclear forces, isospin, exchange nature of nuclear force. **(3L+1T)** **Nuclear Models:** Liquid Drop Model, Evidence of shell structure, single- particle shell model, associated validity and limitations. Brief discussion of Nuclear Collective model. **(5L+3T)**
UNIT-III	**Nuclear Reactions:** Nuclear Reactions: Energy considerations, Cross section for nuclear reactions: statistical considerations. Compound Nucleus and Direct reactions, Nuclear fission and fusion (brief discussion), Neutron scattering cross section (brief discussion). **(5L+3T)** **Alpha Decay:** Range and disintegration energy, Geiger Nuttal law. Fine structure of alpha spectrum. **(3L+1T)**
UNIT-IV	**Beta Decay:** Beta particles: experimental information, neutrino hypothesis, Fermi theory of beta decay, Fermi Kurie plot, Brief survey of *ft* values: allowed and forbidden transitions. Non-conservation of parity in beta decay. Helicity of Neutrino. **(4L+2T)** **Gamma Decay:** Electromagnetic transitions in nuclei, Gamma ray transition probability (qualitative study only). Internal conversion of gamma rays (qualitative study only). Brief discussion of Angular correlation to gamma rays. **(4L+2T)**
UNIT-V	**Introduction to Particle Physics:** Classification of Elementary Particles, Particle interactions. Brief survey of different types of elementary particles (Electrons, protons, neutrons, mesons, hyperons and associated anti-particles). Conservation laws. Spin and parity assignments, isospin, strangeness. C, P, and T invariance and applications of symmetry arguments to particle reactions. Parity non-conservation in weak interactions. **(8L+4T)**
Tutorial	Examples and problems from Reference books will be listed in the Lecture schedule as Tutorials and assignments
Text Books	1. Fundamentals of Nuclear Physics, Varma, Bhandari and Somayajulu, CBS, New Delhi 2005 2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House 3. Introduction Nuclear Physics, W.N. Coltinghar and D.A. Greenword, CUP, Cambridge (2004)
Reference Books	1. Nuclear and Particle Physics: An Introduction, 3rd Edition, B. R. Martin and G. Shaw, Wiley, 2019 2. Nuclear and Particle Physics, W. Demtröder, Springer, 2022 3. Introduction to Nuclear and Particle Physics, 2nd Edition, A. Das and T. Ferbel, World scientific, 2003 4. Nuclear and Particle Physics, B.R. Martin, Wiley, 2006 5. Nuclear and Particle Physics, The Changing Interface, M. Dey and J. Dey, Springer, 1994 6. Nuclear and Particle Physics, C. Amsler, IOP Science, 2015
Suggested E-resources	1. https://www.fisica.net/nuclear/Martin%20-%20Nuclear%20and%20Particle%20Physics%20-%20An%20Introduction.pdf 2. https://www.wiley.com/en-us/Nuclear+and+Particle+Physics%3A+An+Introduction%2C+3rd+Edition-p-9781119344612 3. https://link.springer.com/book/10.1007/978-3-030-58313-2 4. https://www.worldscientific.com/worldscibooks/10.1142/5460#t=aboutBook 5. https://iopscience.iop.org/book/mono/978-0-7503-1140-3

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9125T
Title of the Course	Experimental Techniques in Physics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*This course is designed to understand the importance of sensors, detectors, signal processing units, electronics and vacuum technology for the measurements of various physical properties of materials.*
Learning outcomes	The students would be able to understand and elaborate physical properties of materials: • Abc of sensors and detectors. • Signal processing and required electronic devices. • Vacuum science and thin film technology. • CCD and morphological characterization of materials and surfaces. • Determination of elemental composition of materials and measurements of various physical parameters of semiconductor and magnetic materials.
Syllabus	
UNIT-I	**Sensors & transducers:** mechanical and electromechanical sensors: strain gauge, inductive and capacitive sensors. Thermal Sensors and measurement of temperature: resistance change (RTD, thermistor, metal), thermo-emf (thermo-couple), junction semiconductor, thermal radiation. Magnetic Sensors: magnetic resistive, Hall effect, inductive and eddy current based sensors. Photo cells, LED, Photo detectors. (10+2).

UNIT -II	**Analog Signal Processing:** Signal classifications, functions in analog signal processing, Errors in signal processing, Signal conditioning, Recovery & Conversion, Sample and hold circuits, Impedance matching, filtering and noise reduction, shielding and grounding, Analog to Digital Conversion (ADC), Digital to Analog Conversion (DAC), Box-car integrator, modulation techniques, phased locked loop, lock-in detector, Lock in Amplifier (Principle, typical experimental setup, operation and measurement). (10+2).
UNIT-III	**Vacuum Techniques and Thin Films:** Introductory vacuum concepts: System volume, leak rates, pumping speed, conductance and measurement of system pressure. Vacuum Pumps: Rotary, Diffusion pumps, UHV pumps and materials for UHV, measurement of vacuum, surface preparation and cleaning procedure. Thin film preparation techniques: Thermal evaporation, sputtering, ion-beam, molecular epitaxial and chemical vapor methods. (10+2).
UNIT-IV	**Basics of Imaging techniques:** Field effect transistors and MOS capacitor, Charge coupled Devices and applications, Microscopic techniques in Solid State Physics (Principle, typical experimental setup, operation and measurement): Atomic force Microscopy, Field Ion Microscopy, Scanning Tunneling Microscopy, Electron Microscopy; SEM, TEM & STEM. (10+2).
UNIT-V	**Mass spectroscopy**: Principle, spectrometer setup, operation, typical Mass spectrum and applications. **Physical Property Measurements systems** (Principle, typical experimental setup and measurement)**:** Experimental techniques for the measurement of heat capacity, thermal conductivity, electrical resistivity and ac and dc magnetic susceptibility. (10+2).
Tutorial	Examples and problems from Reference books will be listed in the Lecture schedule as Tutorials and assignments
Text Books	1. Sensors &Transducers by D. Patranabis, PHI, New Delhi 2. Analog Signal Processing by Ramón Pallás-Areny, John G. Webster, Wiley 3. Vacuum Science and Technology by VV Rao, TB Ghosh and KL Chopra, APL, New Delhi 4. Advanced Experimental techniques in Modern Physics by KM Varier, A Jodrph and PP Pradyumnan, PP, New Delhi
Reference Books	1. Microscopy Techniques for Material Science by Ashley Clarke, Colin Nigel Eberhardt, CRC press 2. Experimental techniques in low-temperature physics, by Guy Kendall White, Philip J. Meeson, Oxford University Press
Suggested E-resources	1. Freely available Lecture Notes and YouTube lectures by the Eminent Teachers and Instrument Manuals available on internet.

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9126T
Title of the Course	Plasma Physics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics.
Co-requisites	None
Objectives of the course	*Objective of this course is to find the charged particle motion, theory & characteristics of plasma. Methods to generate plasma in the laboratory and how plasma production is helpful to make fusion reactors will also be discussed. Solar plasma together with the study of solar interior will be taught in detail.*
Learning outcomes	Students will be able to; • Unleash the plasma state as distinct from other three states, develop concepts of Debye screening collective behavior, quasi neutrality. • Derive a set of fluid equations to study plasma properties. • Use fluid equations to study plasma waves, equilibrium and stability. • Understand concepts of plasma resistivity, diamagnetism, and paramagnetism. • Develop Kinetic description of hot plasma, the waves and instabilities in hot plasma. • Understand equilibrium and stability of fusion plasma, magnetic confinement and inertial confinement schemes, Tokamaks, laser fusion. • Learn about Solar plasma and its magneto hydrodynamics, Solar magnetism, Chromospheres and corona, Solar wind and heliosphere, solar eruptions. Solar vibrations, Sunspots and cycle. • Understand 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. • Understand details of solar interior, nucleus transformation and fusion reactions, solar neutrino experiments, Basic of nebular models and the formation of

	the planets, Asteroid, Comets, Meteors.
Syllabus	
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) grad B parallel to B and principle of magnetic mirror. Motion in non-uniform electric field for small Larmour radius. (8+4=12)
UNIT-II	Time varying electric field and polarization drift. Time varying magnetic field adiabatic invariance of magnetic moment (2+1=3) 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. (6+3=9)
UNIT-III	Diffusion across magnetic field. Collision in fully ionized plasma. Plasma resistivity Diffusion in fully ionized plasmas. Solution of Diffusion equation. (4+2=6) Hydromagnetic equilibrium. Concept of magnetic pressure. Equilibrium of a cylindrical pinch. The Benner pinch. Diffusion of magnetic field into a plasma. (4+2=6)
UNIT-IV	Classification instabilities. Two stream instability. The gravitational instability Resistive drift waves. (3+1=4) 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. (5+3=8)
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. (6+3=9) Basic of nebular models and the formation of the planets, Asteroid, Comets, Meteors. (2+1=3)
Tutorials	Tutorials will be based on the syllabus.
Text Books	1. An Introduction to Plasma Physics by F.F. Chen, Plenum Press (1977) 2. Methods in Non-linear Plasma Theory by R.C. Davidson, Academy Press (1972) 3. Plasma Physics in Theory and Application by W.B. Kunkel, Mc Graw Hill (1966) 4. Fundamentals of Plasma Physics by J.A. Bittencoms, Pergamons Press (1986) 5. Principles of Plasma Physics by N.A. Krall and A.W. Trivelpiece, San Fransisco Press (1986)
Reference books	1. Physics of High temperature Plasmas by G. Schimdt 2nd Ed., Academic Press (1979) 2. The framework of Plasma Physics by R.D. Hazeltine & F.L. Waelbroeck, Perseus Books (1998) 3. Introduction to Plasma Physics by R.J. Goldston and P.H. Rutherford, IOP (1995) 4. Plasma Physics via Computer Simulation by C.K. Birdsall, A.B Langdon, CRC Press (2004) 5. Plasma Physics and Engineering by A. Fried and L.A. Kennedy, Taylor and Francis Group (2011)
Suggested E-resources	1. MIT Open Course Ware, Introduction to Plasma Physics I, https://ocw.mit.edu/courses/22-611j-introduction-to-plasma-physics-i-fall-2003/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9127T
Title of the Course	High Energy Physics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics.
Co-requisites	None
Objectives of the course	*This course introduces the basics of the fundamental particles and the strong, weak and electromagnetic forces in the standard model of particle physics. Leptons and quarks interactions, weak and electroweak interactions are discussed in detail. A flavor of Physics beyond standard model and allied experimental methods of high energy physics is also given.*
Learning outcomes	The students would be able to; • Learn about standard model of particle physics with introductory idea of quarks and leptons. • Get knowledge about interactions and fields • Learn invariance principles and conservation laws • Learn physics related to quarks in hadrons • Gain knowledge about quark interactions and QCD along with lepton and quark scattering • Learn basics of weak interactions as well as electroweak interactions in standard model • Understand physics beyond standard model and the experimental techniques in high energy physics
Syllabus	

UNIT-I	**Quarks and leptons:** Standard model of Particle Physics, Particle Classification: femions and bosons, Particles and antiparticles, Free particle wave equation, helicity states: helicity conservation, Lepton flavours, Quark flavours. (4+2=6) *Interactions and fields:* Classical and quantum picture of Interactions, Yukawa theory of quantum exchange, The Boson propagator, Feynman diagrams, Electromagnetic Interaction, Strong Interaction, Weak and electroweak Interactions. (4+2=6)
UNIT -II	**Invariance Principles and Conservation laws:** Parity Operation, Test of Parity conservation, Charge conjugation Invariance, Baryon and Lepton conservation, C P T invariance, C P violation and T violation, Isospin symmetry, Isospin in pion-nucleon systems . (4+2=6) *Quarks in Hadrons*: Charm and beauty; the heavy quarkonium states, The baryon decuplet, Quark spin and colour, The baryon octet, Light vector mesons, Mass relations and hyperfine interactions, Magnetic moment of baryons, Mesons built of light and heavy quarks. (4+2=6)
UNIT-III	**Lepton and quark scattering:** The process of $e^+e^- \rightarrow \mu^+\mu^-$, e^+e^- annihilation to hadrons, Electron-muon scattering, neutrino-electron scattering, Elastic lepton-nucleon scattering, Experimental results on quarks distributions in nucleons. (4+2=6) *Quark Interactions and QCD*: The color quantum number, QCD potential at short distances, QCD potential at large distances, Gluon jets in e^+e^- annihilation, running couplings in QED and QCD, Gluonium and the quark-gluon plasma. (4+2=6)
UNIT-IV	**Weak interactions:** Lepton universality, Nuclear β-decay: Fermi theory, Inverse β-decay: neutrino interactions, Parity non-conservation in β-decay, helicity of the neutrino, The *V-A* interaction, Pion and muon decay, Weak decays of quarks. The GIM model and the CKM matrix. (3+1=4) **Electroweak interactions and the Standard Model:** Divergences in the weak interactions, Introduction of neutral currents, The Weinberg-Salam model, Electroweak couplings of leptons and quarks, Observations on the Z resonance, Fits to the standard model and radiative corrections, Spontaneous symmetry breaking and the Higgs mechanism, Higgs production and detection. (5+3=8)
UNIT-V	**Physics beyond the Standard Model:** Supersymmetry, Supersymmetric SU(5), Proton decay, Neutrino mass: Dirac and Majorana neutrinos, Neutrino oscillations, Magnetic monopoles, Superstrings. (4+2=6) **Experimental Methods:** Accelerators, Colliding beam accelerators, Accelerator complexes, Secondary particle spectators, Interaction of charged particle and radiations with matter, Shower detectors and calorimeters. (4+2=6)
.Tutorials	Tutorials based on the text and reference books
Text Books	1. Introduction to High Energy Physics by D. H. Perkin, Cambridge University Press, 4th Ed. (2000) 2. High energy physics: Volume I by Lucy Flynn, Ny Research Press (2015). 3. Quarks and Leptons: An introductory course in modern particle physics by F. Halzen and A. D. Martin, Wiley (1984). 4. Nuclear and Particle physics by W. E. Burcham and M. Jobes, Pearson (1994). 5. Symmetry principles in particle physics by J. M. Emmerson, Oxford University press (1972).
Reference Books	1. Introduction to High Energy Heavy Ion Collisions by C Heuk-Yin Wong, World Scientific (1994). 2. High energy physics in honor of P. A. M. Dirac in his eightieth year by S. L. Mintz, Springer (2012). 3. An introduction to the standard model of particle physics by D. A. Greenwood and W. N. Cottingham, Cambridge University Press (1998).
Suggested E-resources	1. MIT OpenCourseWare, Particle Physics II, https://ocw.mit.edu/courses/8-811-particle-physics-ii-fall-2005/ 2. MIT OpenCourseWare, Introduction to nuclear and particle physics, https://ocw.mit.edu/courses/8-701-introduction-to-nuclear-and-particle-physics-fall-2020/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9128T
Title of the Course	Solar Physics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*This course is designed to know about Sun-its interior, composition, properties and energy transport. Understanding the activities when the sun is at work and basic elements of space weather. Rudiments of physics underlying the Solar flares and its activities. Solar oscillations and the measurement techniques for solar observation, telescopes and radio observations.*
Learning outcomes	The students would be able to understand: • Structure, composition, interior of the sun and energy transport from the solar interior to the solar atmosphere. • Events and occurrences of the active sun and space weather forecast. • Origin, observations and characteristics of Solar flares, and applications of the principles of magnetohydrodynamics to explain activities of the sun. • Theory and observations of solar oscillations. • Various types of instruments and experimental techniques for Solar observations.
Syllabus	
UNIT-I	**Solar interior:** Structure, composition, and dynamics, radiative transfer, energy transport from the solar interior to the solar atmosphere (4+2=6) **The active Sun and Space Weather:** sunspots, solar active regions, coronal loops, solar prominences, Coronal Mass Ejection (CME): early evolution,

	eruption, space weather consequences (4+2=6)
UNIT -II	**Solar flares:** Standard flare model, radiative processes, flare spectroscopy, triggering mechanisms, HXR and MW bursts (3+2=5). **Solar magnetohydrodynamics:** Derivation of MHD equations, Alfven's flux-freezing theorem, magnetic Reynolds number. Magnetic reconnection, Sweet - Parker model, Petscheck model, 2D & 3D magnetic topologies. (5+2=7).
UNIT-III	**MHD Waves:** shear and compressional Alfven waves, magnetoacoustic modes (4+2=6) Parker turbulent dynamo, mean field magnetohydrodynamics and the dynamo wave solution, flux transport dynamo (4+2=6)
UNIT-IV	**Solar oscillations:** theory and observations (8+4=12)
UNIT-V	**Solar instrumentation:** observables and general difficulties, optical elements for solar observations, solar velocity and magnetic field measurement techniques (4+2=6) Types of solar telescopes, space-based solar observations in (E) UV & X-rays, solar radio observations (4+2=6)
Tutorials	Some of the problems in the text and reference books.
Text Books	1. Physics of the Solar Corona: An introduction with problems and solutions, Markus J Aschwanden, Springer Praxis Books (2005) 2. The Physics of Fluids and Plasmas: An Introduction for Astrophysicists, Arnab Rai Choudhuri. Cambridge University Press (1998) 3. An Introduction to Waves and Oscillations in the Sun, A. Satya Narayanan, Springer New York (2012) 4. The Sun: An Introduction, Michael Stix, Springer Berlin, Heidelberg (2002).
Reference Books	1. Physics of the Sun-A First Course, D.J. Mullan, CRC Press, FL (2009).
Suggested E-resources	1. E-book- Physics of the Sun-A First Course, D.J. Mullan, CRC Press, FL (2009). 2. A course on Solar Physics-Lecture notes by Ashok Ambastha 3. https://sdo.gsfc.nasa.gov/ 4. http://spaceweather.com 5. https://sohoww.nascom.nasa.gov/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9130T
Title of the Course	Materials Science
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The course explores various classes of materials, their properties, control parameters and an understanding of their phase diagrams. It also includes discussions on some technologically important novel materials.*
Learning outcomes	The students would be able to understand: • Phase diagrams, solubility limit. Basic as well as salient features of Phase diagram, microstructure. Phase equilibria, binary isomorphous systems.. • Structure and properties various types of ceramics, ceramic phase diagram, brittle fracture of ceramics, • Properties of glasses, glass ceramic, clay products, characteristics of clay, refractories, abrasives, cement. • Chemistry of polymers: molecular configuration. stress-strain behavior, thermoplastic and thermosetting polymers, viscoelasticity, deformation of elastomers, impact strength, fatigue, strength and hardness. • Particles and fiber reinforced composites, polymer-matrix, metal-matrix, ceramic-matrix composites, • Carbon-carbon composites, laminar composites, sandwich panels. • Soft and hard magnetic materials, magnetic thin films, multilayers - DMS, GMR, and CMR magnetic nanoparticles. Measurement of particle size density- porosity- lattice constant using X-ray, Mössbauer spectroscopy and VSM technique.
Syllabus	

UNIT-I	**Phase diagrams:** Definitions and basic concepts. Solubility limit. Phases, microstructure. Phase equilibria. Equilibrium phase diagram. Binary isomorphous systems. Interpretations of phase diagrams. Binary eutectic systems. Development of microstructures in eutectic alloys. The Fe-Fe; C phase diagram, Development of microstructures in iron-carbon alloys. Phase transformations: Kinetics of phase transformation, metastable vs equilibrium states. **(10+4)**
UNIT-II	**Ceramics:** Ceramic structure, ceramics density calculations, Silicate Ceramics, imperfections in ceramics, ceramic phase diagram of Al_2O_3-Cr_2O_3 system, Brittle fracture of ceramics, stress, strain behaviours (qualitative) **(4+2)** **Glasses:** Properties of glasses, glass forming. Heat treating glasses glass ceramic. Clay products. Characteristics of clay. Composition of clay products. Refractories. Abrasives, Cement. **(4+2)**
UNIT-III	**Polymers**: Hydrocarbon molecules. Polymer molecules. The chemistry of polymer molecules. Molecular weight and shape. Molecular structure. Molecular configuration. Stress-strain behaviour. Thermoplastic and thermosetting polymers, viscoelasticity. Deformation of elastomers. Impact strength, fatigue, strength and hardness. **(7+4)**
UNIT-IV	**Composites:** Particles Reinforced composites, large particles composites, dispersion strengthened composites, Fiber Reinforced Composites: Influence of fiber length, orientation and concentration. The Fiber phase, matrix phase, Polymer-matrix, Metal-Matrix, Ceramic-Matrix Composites, Carbon-Carbon composites, laminar composites, sandwich panels. **(7+4)**
UNIT-V	**Magnetic Materials:** Soft magnetic materials, hard magnetic materials, qualitative discussion of magnetic thin films, multilayers - DMS, GMR, CMR (no derivations). Magnetic nanoparticles, Measurement of Particle size density- porosity- lattice constant using X-ray. Working principles of magnetic characterization using Mössbauer spectroscopy (qualitative discussion only), and VSM (Low and high field magnetic field and temperature) (qualitative discussion only). **(8+4)**
Tutorials	Some of the problems in the text and reference books.
Text Book	1. Material Science and Engineering: An Introduction : William D. Callister Jr., John Wiley & Sons. 2. Introduction To Magnetic Materials 2nd Edition: Cullity and Graham 3. Jagdish Varma, Roop Chand Bhandari, D.R.S. Somayajulu : Fundamentals of Nuclear Physics
Reference book	1. Introduction to Materials Science for Engineers; 8th Edition, James F. Shackelford, Pearson 2. Foundations of Materials Science and Engineering; 5th Edition, William F. Smith and Javad Hashemi; McGraw-Hill Education 3. The Science and Engineering of Materials, 7th Edition, Donald R. Askeland, Wendelin J. Wright 4. Materials Science and Engineering: A First Course, V. Raghavan
E-resources/Contents	1. https://ocw.mit.edu/courses/3-091-introduction-to-solid-state-chemistry-fall-2018/resources/lecture-1/ 2. https://archive.nptel.ac.in/courses/113/107/113107078/ 3. https://ocw.mit.edu/courses/3-012-fundamentals-of-materials-science-fall-2005/pages/syllabus/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9131T
Title of the Course	Quantum Theory of Solids
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*This is an advance course for the theoretical study of physics of materials. Mathematical formulation of a few theoretical techniques to deal with many particle interactions in physics at zero and finite temperature are developed and illustrated. The course is very useful to invoke recent trends of theoretical physics in general and materials physics in particular.*
Learning outcomes	The students of Physics, Chemistry major, materials science, biochemistry would be able to understand: • Basic mathematical framework to deal with interactions in many particle systems at zero and finite temperature. • The techniques of second quantization and its applications to understand behavior of solids.
Syllabus	
UNIT-I	**Scales, Complexity and Quantum Fields:** Time scales, Length scales, Particle number, Complexity and Emergence, Overview of Quantum fields and collective quantum fields, Harmonic Oscillator: A zero dimensional field theory, Collective modes: A charged harmonic oscillator in electric field, The Thermodynamic limit $L\rightarrow\infty$; Continuum limit $a\rightarrow\infty$ (8+4=12)

UNIT-II	**Conserved Particles and Second Quantization:** Commutation and Anti-commutation Algebra; Field as particle creation and annihilation operators, The Jordan Wigner Transformation, 1-D Heisenberg model, Non interacting particles in thermal equilibrium, Gauges and the Electromagnetic field quantization (8+4=12)
UNIT-III	**Green function at Zero Temperature:** Representations, interaction representation; S-Matrix, Wicks theorem and Green functions; Green functions for free Fermions and Free bosons, Adiabatic concept; Many particle Green function, Example of electron-phonon interaction (8+4=12)
UNIT-IV	**Zero Temperature Feynman Diagrams and Self-energy :** Derivation and Feynman diagrams; Feynman diagram equations; Feynman diagrams in momentum space; Hartree-Fock energy, Self-energy, Hartree-Fock self-energy (8+4=12)
UNIT-V	**Finite Temperature Many Body Physics:** Imaginary time and Green function, Matsubara representation, Feynman diagram expansion; Feynman rules from functional derivatives and rules in momentum space; Use of Matsubara technique-HF at finite temperature; Interacting electrons and phonons (8+4=12)
Tutorial	Simple problems from the text book and solution of the intermediate steps, is the derivatives cover in the 5 units.
Text Book	1. Many-Particle Physics, 3rd Edn., G.D. Mahan, Kluwer Academic/Plenum Press (2008).
Reference book	1. Quantum Theory of Many Particle Systems, A.F. Fetter and D. Walecka, Dover Publications, Kolkata (2003). 2. Solid State Physics, D.W. Snoke, 1st Edn., Pearson Education Inc. Addison-Wesley, New Delhi (2009). 3. Introduction to Many Body Physics, P. Coleman A monogram, (2013).
E-resources/Contents	1. Lectures on Quantum Chemistry visit nptel on http://nptel.iitm.ac.in 2. Quantum Condensed Matter Physics, C. Nayak http://stationq.cnsi.ucsb.edu/ nayak/courses.html, 2004.

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9132T
Title of the Course	Quantum Field Theory
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The students are exposed to the basic elements of quantum field theory. The student shall understand the methods to quantize a field. Moreover, the student can get the idea of Feynman rules and draw the diagrams to understand the kinematics underlying a physical process of relativistic fields. The students will identify various interaction processes, write and compute the matrix elements.*
Learning outcomes	The students will be able to understand: • The mathematical instruments and roadmap to quantize fields. • The concepts, need and usage of second quantization techniques. • The expansion of S matrix, identification of interaction processes and write the Feynman diagrams. • The concept of normal ordering, Wicks theorem, Feynman rules. • Method to evaluate the cross sections of interaction processes and propagators.

Syllabus	
UNIT-I	**Electromagnetic Field:** Particles and fields, EMF without charges, Harmonic oscillator, Dipole interactions, EMF with chargesClassical and quantum electrodynamics, radiative transitions, Thomson scattering **(8+4=12)**
UNIT-II	**Lagrangian Field Theory:** Relativistic notations, Units and conversion, Classical Lagrangian field theory, Quantized Lagrangian field theory, Symmetries and conservation laws, Real KG field, Complex KG field, Covariant commutation relations, Meson propagator **(8+4=12)**
UNIT-III	**Dirac Field and Covariant Theory of Photons :** Dirac field, Fermion propagator, Number representation for Fermions, Dirac equation, Second quantization, The Feynman Fermion propagator, Photons-Classical field, Covariant quantization, Photon propagator **(8+4=12)**
UNIT-IV	**Interacting Fields and Feynman Rules:** Perturbation theory: examples, S-matrix expansion, Normal ordering, Wick's theorem, Feynman diagram and rules in QED **(8+4=12)**
UNIT-V	**Feynman diagrams and cross sections (8 Lectures)** Feynman diagram in momentum and configuration space, Feynman diagrams and scattering cross sections for Compton, Moller and Bhabha scattering, Scattering by external field **(8+4=12)**
Tutorial	1. The intermediate steps in the derivations 2. The simple trace calculations 3. Simple identities used in the general derivation of propagator and matrix elements. Properties of gamma matrices.
1. Text Book	1. Relativistic quantum mechanics, W. Greiner, Springer, Berlin (2010). 2. An introduction to quantum field theory, M. E. Peskin and D.V. Schroeder, CRC Press, Taylor & Francis Group, FL (2018).
Reference book	1. Quantum field Theory, L.H. Ryder, Cambridge University Press (2003). 2. Quantum Field Theory, F. Mandl & G. Shaw, John-Wiley & Sons, Interscience Publ. (2010). 3. Quantum Field Theory, C. Itzykson and J-B. Zuber, McGraw-Hill Inc., New Ypok (2010). 4. A First book of quantum field theory, 2nd Edn,, A. Lahiri and P.B. Pal, Narosa Publ. house. New Delhi (2015).
E-resources	1. https://web.physics.ucsb.edu/~mark/ms-qft-DRAFT.pdf 2. https://www.damtp.cam.ac.uk/user/tong/qft/qft.pdf 3. http://home.ustc.edu.cn/~gengb/200923/Peskin,%20An%20Introduction%20to%20Quantum%20Field%20Theory.pdf

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9133T
Title of the Course	Laser and Spectroscopy
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The subject aims to provide the student with:* *To enable the students to gain the basic knowledge of molecular spectroscopy Raman spectroscopy and their applications* *Understand the Lasing Concepts with different types of lasers and their applications in different fields*
Learning outcomes	At the end of the course the student will be able to : • Understand the basic of molecular spectroscopy and its characterisations. • Apply the concept of Raman spectroscopy to various fields including engineering and medicine. • Proficient to understanding fabrication and working of different types of lasers. • Learn the applications of lasers in various fields
Syllabus	
UNIT-I	**Lasers: (2+1)** Coherence, spatial and temporal coherence, measurement of spatial and temporal coherence, coherence time, coherence length, line width and monochromaticity; coherence time and line width via Fourier analysis, complex degree of coherence and fringe visibility in Young's double hole experiment. **Laser rate equations: (2+1)**

	Basic structure of a Laser, theory of laser oscillations, round-trip power gain and threshold condition. Rate equations for two, three and four level lasers; variation of laser power around threshold, optimum output coupling. **Optical resonators: (2+1)** Plane-parallel resonator, spherical resonator, confocal resonator, unstable resonator, losses in optical resonator, quality factor *Q*. **Line broadening mechanisms and laser modes: (2+1)** Line shape broadening: Doppler broadening, collision broadening, natural radiative lifetime broadening, homogeneous and inhomogeneous broadening. Laser modes: Longitudinal and transverse modes, experimental arrangement for mode selection.
UNIT-II	**Types of Lasers: (8+4)** Types of Laser: Mention types of laser like Solid, Liquid and Gas laser, etc. Construction and working with energy level diagram/chemical reactions of Solid state Laser: Ruby laser & Nd-YAG Laser, Gas Laser, He-Ne, Excimer Laser, Liquid Laser- Dye Laser (Rhodamine 6-G) , Chemical Laser: HF Laser, Qualitative discussion of X -Ray Laser and free electron laser
UNIT-III	**Applications of Lasers: : (8+4)** Industrial applications: Cutting, Drilling and Welding, Laser printing: Construction and working of laser printer along with either ray diagram or with actual 3-d diagram, Research and development applications, Lithography: Definition of lithography. Photolithography, Qualitative explanation of Deep UV Lithography using Excimer laser with block diagram, Laser cooling: Principle of laser cooling. Working of laser cooling (Doppler cooling), Laser fusion: Brief explanation of condition for fusion. Explanation of Laser Inertial Fusion Energy (LIFE). Mention of 2 laser fusion devices namely SHIVA and NOVA, Biomedical applications: Endoscopy: Define endoscopy. Explain the procedure in brief with block diagram, Dentistry: Qualitative explanation of any cavity treatment, root canal, Light Detection and Ranging (LIDAR): Measurement of atmospheric pollutants.
UNIT-IV	**Spectroscopy: (4+4)** Different energy levels in molecules – Brief explanation of Electronic, Vibrational & Rotational levels with energy level diagram. Qualitative discussion on (Mention of the expression) Electronic, Vibrational & Rotational energy. Mention of expression for harmonic oscillator, Discussion on zero-point energy, Representation of energy levels in potential energy curve and Discussion on vibrational spectra with selection rule. Short note on anharmonic oscillator. **Spectroscopic Experimental Techniques: (4+4)** Sources and their types, Detectors, IR- spectrometer and applications, UV- Visible absorption and fluorescence spectrophotometers and applications, Single and double beam spectrophotometer, Fluorescence and Phosphorescence, Spectro fluorometer, IR spectrophotometer, Fourier transform infrared spectroscopy, Nuclear magnetic resonance (NMR) spectroscopy, Time- correlated single photon counting (TCSPC).
UNIT-V	**Raman Spectroscopy: (8+4)** Scattering of light: Coherent and incoherent scattering with examples. Raman effect, Stoke's and anti Stoke's lines, Characteristics of Raman spectra Experimental study of Raman effect: Experimental set up, Description and working. Classical theory of Raman effect based on polarisability (qualitative), Quantum theory of Raman effect based on law of conservation of energy. Rotational Raman spectra (qualitative)- Energy expression, selection rule and spectra, Vibrational Raman spectra (qualitative) - Energy expression, selection rule and spectra Resonance Raman effect: Explanation Comparison between Raman effect and Resonance Raman effect, Raman Spectrometer, Applications of Raman spectroscopy (qualitative): Detailed discussion of role of Raman spectroscopy in Forensic science, Environmental studies: Pollution monitoring. Industrial applications: Semiconductor industry, Manufacturing industry.
Tutorials	Problems based on the text and reference books.

Text Book	1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash, Tata McGraw-Hill Publishing Company Limited, New Delhi. 2. Spectroscopy by H. Kaur, Pragati Prakashan, Meerut. 3. Lasers: Theory & Applications by K. Thyagarajan and A.K.Ghatak, Springer (1981). 4. Laser and Fundamentals by W.T.Silfvast, Cambridge university Press (2004). 5. Lasers and Nonlinear Optics by B.B.Laud, John Wiley & Sons Inc (1985)
Reference book	1. Introduction to Molecular Spectroscopy, G M Barrow, McGraw Hill. 1962 2. Modern Spectroscopy, Hollas, Michael J, Wiley, 4th Ed-2003 3. LASERS: Principles, Types and Applications by K.R.Nambiar, New Age international Publishers.
E-resources	1. https://onlinecourses.nptel.ac.in/noc22_cy23/preview 2. https://nptel.ac.in/courses/104101099 3. https://www.youtube.com/watch?v=pXVS0Q0WuUY 4. https://www.youtube.com/watch?v=jzFnvSPbwzM 5. https://nptel.ac.in/courses/104106122 6. https://edu.rsc.org/resources/spectroscopy-videos/1041.article

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9135T
Title of the Course	Microwave Electronics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The subject aims to provide the student with:* *An understanding of microwave waveguides and transferred electron devices.* *To distinguish between different types of microwave tubes, their structure and principles of microwave power generation.* *Describe the microwave properties and its applications.* *Understand the basics of Antenna measurements and radiation pattern.* *An ability to perform microwave measurements.*
Learning outcomes	The students would be able to: • Understand the significance of microwaves and microwave transmission lines. • Analyze the characteristics of microwave tubes and compare them. • Be able to list and explain the various microwave solid state devices. • Can set up a microwave bench for measuring microwave parameters.
Syllabus	

UNIT-I	**Introduction :** Introduction to microwaves and its frequencies spectrum, Necessity of microwaves and their applications . **(1)** **Wave Guides:** (a) **Rectangular wave guides :** Wave equation & its solutions, TE and TM modes. Dominant mode and choice of wave guide dimensions, Methods of excitation of wave guide, Power transmission and power losses .**(3+2)** (b) **Circular wave guides:** Wave equation and its solutions, TE, TM and TEM modes, Power transmission and power losses. **(4+2)**
UNIT-II	**Resonators:** Resonant modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Frequency meter, Dielectric resonators. **(3+2)** **Striplines:** Introduction to mircostrip lines, Characteristic impedance of microstrip lines, Losses in microstrip lines, Quality factor of microstrip lines, Basics of parallel and coplanar striplines. **(3+1)** **Transferred electron devices:** Gunn effect, Differential negative resistance, Two-valley model theory (No derivation), Microwave generation using Gunn diode. **(2+1)**
UNIT-III	**Microwave linear beam tubes:** Space charge spreading of an electron beam, Beam focusings, Velocity modulation, Two cavity Klystron, Reflex Klystron and efficiency of Klystrons, Slow wave structure of helix TWT, Amplification process and working principle of TWT. **(8+4)**
UNIT-IV	**Microwave crossed field tube:** Types and description, Theoretical relations between electric and magnetic field of oscillations for magnetrons. Modes of oscillations and operating characteristics of magnetrons. Construction and working principle of Gyrotron. **(4+2)** **Ferrites :** Microwave propagation in ferrites, Faraday rotation, Devices employing Faraday rotation (isolator, gyrator, circulator). Introduction to single crystal ferromagnetic resonators. **(4+2)**
UNIT-V	**Microwave test equipment:** Measurement of power, frequency, attenuation, impedance and VSWR. Reflectometer, Antenna measurements and radiation pattern. **(5+3)** **Complex permittivity of materials and its measurement:** Definition of complex permittivity of solids, Dielectric properties of materials using shift of minima method. **(3+1)**
Tutorials	Problems based on the text and reference books.
Text Book	1. Microwave Introduction to circuits, Devices and Antennasby M.L. Sisodia& Vijay Laxmi Gupta (New Age International) (2007). 2. Microwave Devices and Applications by Dinesh C. Dube (Narosa) (2011). 3. Microwave devices and circuits by Samuel Y. Liao (Pearson) (1990).
Reference book	1. Foundations of Microwave Engineering by R.E. Collin (McGraw Hill) (1992). 2. Electromagnetic Waves & Radiating System-Jorden &Balmain (PHI Learning) (1968). 3. Theory and Applications of Microwaves A.B. Brownwell& R.E. Beam (McGraw Hill) (1947). 4. Introduction to Microwave Theory by Atwater (McGraw Hill) (1962). 5. Principles of Microwave circuits by G.C. Montogmetry (McGraw Hill) (1948).
E-resources	1. http://referenceglobe.com/kpsslp/support/upload_videos/microwave-devices-and-circuits-samuel-liao_1588230228.pdf 2. http://alunoeletrica.eng.ufba.br/material/eletromagnetismoaplicado/livros/pozar.pdf

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9136T
Title of the Course	Fibre optics and Communication
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	Basic knowledge of semiconductors devices and material science: such as diodes, transistors, amplifiers, oscillators and power supplies along with common electrical components & devices and optics & glasses.
Objectives of the course	*This course is designed to understand the importance of fiber communication in internet and information technology.*
Learning outcomes	The students would be able to understand and elaborate the functioning of optical fiber and communication systems.
Syllabus	
UNIT-I	**Optical fiber Communications:** Historical development, Introduction-general optical fiber communication system- basic optical laws and definitions, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, optical modes and configurations -mode analysis for optical propagation through fibers modes in planar wave guide-modes, Phase and group velocity, cylindrical optical fiber-transverse electric and transverse magnetic modes: Classification of optical fiber, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fiber Materials, Photonic crystal fibers. **(8+4=12)**

UNIT-II	**Transmission characteristics of optical fiber:** Attenuation-absorption-scattering losses-bending losses-core and cladding losses-signal, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, dispersion –inter symbol interference and bandwidth-intra model dispersion, Chromatic dispersion, **Intermodal dispersion:** Multimode step index fiber, dispersion optimization of single mode fiber-characteristics of single mode fiber-R-I Profile cutoff wave length-dispersion calculation-mode field diameter. Optical Fiber Connectors: Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers. **(8+4=12)**
UNIT-III	**Optical sources:** Energy Bands, Intrinsic and extrinsic material-direct and indirect band gaps, Light Emitting diodes: LED Structures, power-light source materials-modulation of LED-LASER diodes-modes and threshold conditions-Rate equations-external quantum efficiency-resonant frequencies-structures and radiation patterns-single mode laser-external modulation-temperature effort., LED Power, Rate equation, Resonant frequencies, Laser Diode structures and Radiation Patterns: Single mode lasers. **Photodetectors:** Physical principles of Photodiodes, PIN photo detector-Avalanche photo diodes-Photo detector noise-noise sources-SNR-detector response time-Avalanche multiplication noise-temperature effects, comparisons of photo detectors. **Optical Receiver:** Optical Receiver Operation: Error sources, Front End Amplifiers, Receiver sensitivity, Quantum Limit. **(8+4=12)**
UNIT-IV	**WDM Concepts and Components:** Overview of WDM: Operational Principles of WDM, WDM standards, Mach-Zehnder Interferometer Multiplexers, Isolators and Circulators, Fiber grating filters, Dielectric Thin-Film Filters, Diffraction Gratings, Active Optical Components, tunable light sources, **Optical amplifiers**: Basic application and Types, Semiconductor optical amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers, Wideband Optical Amplifiers. **(8+4=12)**
UNIT-V	**Optical Networks:** Optical network evolution and concepts: Optical networking terminology, Optical network node and switching elements, Wavelength division multiplexed networks, public telecommunication network overview. Optical network transmission modes, layers and protocols: Synchronous networks, Asynchronous transfer mode, OSI reference model, Optical transport network, Internet protocol, Wavelength routing networks: Routing and wavelength assignment, Optical switching networks: Optical circuit switched networks, packet switched networks, Multiprotocol Label Switching, Optical burst switching networks, Optical network deployment: Long-haul networks, Metropoliton area networks, Access networks, Local area networks. **(8+4=12)**
Tutorials	Problems based on the text and reference books.
Text Book	1. J. C. Palais, "Fiber Optic Communication," Pearson Prentice Hall, 2013. 2. S. O. Kasap, "Optoelectronics and Photonics: Principles and Practices," Pearson Prentice Hall, 2011. 3. J. Powers, "An Introduction to Fiber Optic Systems," TMH 2010. 4. G. Keiser, "*Optical Fiber Communication*," Mc Graw Hill 2013.
Reference book	1. G. Keiser, "Optical Communications Essentials," Mc Graw Hill 2013. 2. G. P. Agrawal, "Fiber-Optic Communication Systems," John Wiley & Sons, 2011. 3. J. M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson 2011. 4. B. P. Pal, "*Fundamentals of Fibre Optics in Telecommunication and Sensor Systems*," New Age International Publishers 2006.
E-resources	1. Freely available Lecture Notes by the Eminent Teachers and Instrument Manuals available on www.google.com 2. Optical Fiber Communication: The Science Behind It (hfcl.com) 3. https://www.utdallas.edu/~torlak/courses/ee4367/lectures/FIBEROPTICS. 4. https://www.antaira.com/Blog-Four-Advantages-of-Fiber-Optic-Communications 5. https://mrcet.com/downloads/digital_notes/ECE/III%20Year/FIBER%20OPTICAL%20COMMUNICATIONS

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9137T
Title of the Course	Non Linear Physics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The course will introduce the students to the basic concepts of nonlinear systems covering dynamical systems, dissipative systems, Hamiltonian systems, chaos, and soliton. These concepts will be demonstrated using simple models based on ordinary & partial differential equations and discrete maps.*
Learning outcomes	The students would be able to: • Gain the knowledge about concepts and methods of dynamical systems, dissipative systems that acquired during this course will be useful and applicable in almost all branches of science • Gain knowledge about the Hamiltonian systems. • Gain knowledge of partial differential equation in linear and nonlinear systems • Gain knowledge of advanced topics such as quantum chaos, soliton, synchronization etc. • To learn the different analytical techniques and the geometrical intuition of local & global behaviour to understand the evolution of complex nonlinear systems.

Syllabus	
UNIT-I	Introduction to dynamical systems: Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincare section and iterative maps. **(8+4=12)**
UNIT-II	Dissipative Systems: One - dimensional noninvertible maps, simple and strange attractors, iterative maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents, higher dimensional systems, Henon map, Lorenz equation. Fractal geometry, generalized dimensions, examples of fractals. **(8+4=12)**
UNIT-III	Hamiltonian Systems: Integrability, Liouville's theorem, action - angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, concepts of chaos and stochasticity. **(8+4=12)**
UNIT-IV	Partial different equations: linear and nonlinear, diffusive and dispersive; boundary value problems; methods of separation of variables, characteristics; inverse scattering; symbolic computation; similarity and Backlund transformations. **(8+4=12)**
UNIT-V	Advanced Topics: Introduction to synchronization and pattern formation, quantum chaos, cellular automata and coupled map lattices, solitons and completely integrable systems, turbulence. **(8+4=12)**
Tutorials	Problems based on the text and reference books.
Text Book	1. Introduction to Dynamics by Percival and D. Richards, Cambridge University Press (1982) 2. Perspective of Nonlinear Dynamics I by E.A. Jackson, Cambridge University Press (1992) 3. An introduction to Chaotic Dynamical System by R.L.Devaney, 2nd Ed. CRC Prress (2003) 4. Nonlinear dynamics: Integrability, Chaos and Patterns by M. Lakshmanan and S. Rajasekar, Springer-Verlag (2003). 5. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering by S. H. Strogatz, Westview Press (2001). 6. Nonlinear Science:Emergence and Dynamics of Coherent Structures by A. Scott, 2nd Ed. Oxford Univ. Press (1999)
Reference book	1. Chaos by Hao Bai-lin, World Scientific Publishing (1984) 2. Regular and Stochastic Motion by A.J. Lichtenberg and M.A. Lieberman, Springer, NY (1983) 3. Chaos in Classical and Quantum Mechanics by M.C. Gutzwiller, Springer, NY (1990) 4. CHAOS: An Introduction to Dynamical Systems by K. Alligood, T. Sauer and J.A. Yorke, Springer (1996) 5. Solitons: An Introduction by P. G. Drazin & R. S. Johnson, Cambridge University Press (1989)
E-resources	1. MIT OpenCourseWare, Nonlinear Dynamics: Chaos, https://ocw.mit.edu/courses/12-006j-nonlinear-dynamics-chaos-fall-2022/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9138T
Title of the Course	Nanoelectronics
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*The course intends to give students a broad understanding of fundamentals, fabrication technologies and applications of nanoscale structures*
Learning outcomes	The students would be able to understand • Physical background and applications of nanoelectronics. • Electrical and optical properties of materials and nanostructures, • Fabrication of nanostructures, nanoelectronic devices including resonant-tunneling devices, transistors, and single-electron transfer devices
Syllabus	
UNIT-I	**Free and confined electrons** Free electrons in 1D and 3D, electrons confined to a bounded region of space and quantum numbers, partially confined electrons in finite potential well; finite rectangular well and parabolic well, Quantum dots, wires and wells **(8+4)**

UNIT-II	**Tunnel Junction and their applications** Tunneling through a potential barrier, potential energy profile for material interfaces between the metal-insulator, metal- semiconductor and metal-insulator- metal Junctions, application of tunneling in field emission, double barrier tunneling and resorance tunneling dioxide **(8+4)**
UNIT-III	**Nanoscale MOSFETs** Challenges in miniaturization, quantum effects, thin oxides, random dopant fluctuations, tunneling and subthreshold currents, power density, hot electron effects, fundamental limits of MOS operations, MODFET (Modulation Doped FET), GaN based HEMT (High Electron Mobility Field Effect Transistors). **(8+4)**
UNIT-IV	**Molecular Nanoelectronics** Single molecular devices, Molecular nanowires, charge transport in organic materials, fabrication techniques for molecular electronics, organic LEDs, organic FETs, carbon nanotube and grapheme-based FETs, Silicon nanowire-based FETs **(8+4)**
UNIT-V	**Single Electron Tunneling Phenomena and Devices** Single electron tunneling, charging energy, tunneling rates, single electron transistor, Coulomb blockade, Coulomb staircase, Bloch oscillations, negative differential resistance, resonant tunneling diode and resonant tunneling transistor. **(8+4)**
Tutorials	Problems based on the text and reference books.
Text Book	1. K. Goser, P. Glosekotter and J. Dienstuhl, Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Springer 2. W. Rainer, Nanoelectronics and Information Technology, Wiley 3. K.E. Drexler, Nanosystems, Wiley 4. M.S. Dresselhaus and G. Dresselhaus, Science of fullerenes and carbon nanotubes, Academic press 5. George W. Hanson, Fundamentals of Nanoelectronics, Pearson
Reference book	1. S. Datta, “Lessons from Nanoelectronics: A New Perspective on Transport (Lessons from Nanoscience:a Lecture Notes Series) World Scientific, 2012 2. V. Mitin, V. Kochelap, and M. Stroscio “Introduction to Nanoelectronics: Science, Nanotechnology,Engineering, and Applications”, Cambridge University Press, 2008. 3. C. P. Poole and F. J. Owens, “Introduction to nanotechnology”, John Wiley & Sons, 2003
E-resources	1. https://ocw.mit.edu/courses/6-701-introduction-to-nanoelectronics-spring-2010/ 2. https://ocw.mit.edu/courses/2-57-nano-to-macro-transport-processes-spring-2012/resources/lecture-1-intro-to-nanotechnology-nanoscale-transport-phenomena/ 3. https://archive.nptel.ac.in/courses/117/108/117108047/

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9140P
Title of the Course	Modern Physics Lab
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practicum 80+40=120. The 80 hrs for the hands on experiments, observations and record of the data, 20 hours for the experiment, instruments demonstration, lab practices and 20 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*This experimental course introduces the student to the use of instruments used in nuclear and atomic Physics as well as to study properties of materials. The students learn the order and magnitude of the spectral quantities associated instrumental errors, permissible errors. They can develop the skills is improve the accuracy of the instruments and measure techniques. They also learn relative performance of alternative spectroscopic methods.*
Learning outcomes	The students would be able, • To study random events for a Co-60 source using a G.M. counter • To determine end point energy of beta-particles of the given radioactive source • To study absorption coefficient of lead for cobalt 60 gamma rays using G.M. counter • To calibrate the given scintillation counter and measure the energy emitted by an unknown radioactive source • To calibrate the given scintillation counter and calculate the resolution of the counter using Cesium-137 source • To determine g-value of electron using ESR • To measure resistivity of a semi-conductor at different temperatures

<table>
<tr><td></td><td>• To measure magnetic susceptibility of a paramagnetic solution
• The necessary instruments required in MP experiments
• The accuracy and resolution of instruments
• To deal with errors in spectroscopic methods and minimization of errors
To deal with radioactive sources in lab</td></tr>
<tr><td colspan="2">Syllabus</td></tr>
<tr><td></td><td>Students are required to complete at least eight experiments. Students are expected to carry out the experiment after understanding theoretical principle behind each experiment. The results of the experiments carried out by the students will be reported to the teacher in regular manner in a specified format written in the Practical records book.

1.To study random events for a Co-60 source using a G.M. counter
2. To determine end point energy of beta-particles of the given radioactive source
3. To study absorption coefficient of lead for cobalt 60 gamma rays using G.M. counter
4. To calibrate the given scintillation counter and measure the energy emitted by an unknown radioactive source
5. To calibrate the given scintillation counter and calculate the resolution of the counter using Cesium-137 source
6. Determination of g-value of electron using ESR
7. Measure resistivity of a semi-conductor at different temperatures by Four Probe method
8. Measurement of magnetic susceptibility of a paramagnetic solution by Quincke’s method.
9. Determination of the Curie temperature of the given ferrite sample.
10. To calibrate the given Mossbauer spectrum and hence determine the magnetic hyperfine field of Fe
11. To calibrate the given Mossbauer spectrum and hence determine the isomer shift and electric field gradient of the given sample
12. To determine the magnetic parameters (saturation magnetization, coercivity, retentivity) of the given ferromagnetic sample
13. Study of the surface of the given sample using AFM
14. To measure the density and hence calculate the porosity of the given sample
15. To study the temperature dependence of Hall coefficient of n- and p- type semiconductors.
16. Verification of Bragg’s law and determination of wavelength/energy spectrum of X-rays.

Any other experiment designed by the faculty may also be included based on modern physics.</td></tr>
<tr><td>Text Book</td><td>1. A practical approach to nuclear physics by K. M. Varier, Narosa (2019).
2. Experiments in Modern Physics by A. C. Melissinos and J. Napolitano, Academic Press (2003)
3. Instrumentation Measurements and Analysis by B. C. Nakra and K. K. Chaudhary Tata McGraw Hill (2002)</td></tr>
<tr><td>Reference book</td><td>1. Measurement, Instrumentation and Experiment Design in Physics and Engineering by M. Sayer and A. Man singh, Prentice Hall (2000)
2. Semiconductor Measurements and Instrumentation by W. R. Runyan, McGraw Hill (2000)</td></tr>
<tr><td>E-resources/Weblinks</td><td></td></tr>
<tr><td>EoSE</td><td>The duration of the examination shall be six hours wherein the student has to perform any one experiment. The marks distribution shall be the following:
1. One experiment: 50
2. Viva Voce :20
3. Evaluation of the record book of experiments performed in the semester: 10</td></tr>
</table>

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9141P
Title of the Course	Materials Synthesis Lab
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practicum: 80+40=120. The 80 hrs for design and fabrication of analog/digital electronic circuits and for algorithm, programme writing and execution of ALP and 20 hrs for testing electronic circuits and debugging tools. 20 hrs for diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Fundamental knowledge of Physics and Chemistry
Co-requisites	Basics knowledge of materials science.
Objectives of the course	*This course introduces students to the building blocks and processes involved in fabrication of nanomaterials. In particular, students will develop a critical understanding of the relationship between synthesis and resultant material's properties. Upon completion of this course, students will have attained the appropriate foundation knowledge for future courses in the program.*
Learning outcomes	The students would be able to: • Understand different methods for the synthesis of nanomaterials and bulk materials using Microwave Irradiation/Sol-Gel/Co-precipitation/hydrothermal Method/ solid state reaction routes etc. along with thin film deposition methodology. • Characterization of materials by analytical techniques like XRD, FTIR, EDX, Spectroscopic methods such as UV-Vis, PL, Dielectric, I-V characteristics, DST/DTA, photocatalytic etc. • Basic laboratory safety procedures, handling of chemicals, operation of instruments.
Syllabus	

	This paper is based on a Project Work, in which students will synthesize some materials & characterize them with standard tools, interpret their results and come up with a dissertation. **List of experiments** Preparation of nanomaterials like Fe, silver, different types of nano-oxides such as: Al2O3, TiO2, ZnO, Ferrites and perovskites, nanotube and wire formation, carbon nanotubes, graphene etc. using methodologies given below and their characterization with standard techniques. **Preparation techniques-1:** Top-down and bottom-up synthesis approach, physical and chemical techniques for nanomaterial synthesis, sol-gel, hydrothermal, freeze drying, intercalation, attrition, mechanical alloying and mechanical milling, ion implantation, Gas phase condensation, Chemical vapour deposition, fundamentals of nucleation growth, controlling nucleation & growth **Preparation techniques-2:** Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerisation, templated synthesis, and confined nucleation and growth. Biomimetic Approaches: polymer matrix isolation, surface-templated nucleation and/or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition. **Preparation techniques-3:** Vapor deposition and different types of epitaxial growth techniques pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). **Characterization techniques:** X-Ray Diffraction, X-Ray Reflectivity, Scanning Electron Microscopy, Transmission Electron Microscopy, High Resolution Transmission Electron Microscopy, Field Emission Scanning Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Spectroscopy / Microscopy, Photoluminescence Spectroscopy, Electrochemical Impedance Spectroscopy, Polarized neutron Reflectivity, Differential thermal and Gravimetric Analysis, Dynamic Mechanical Analysis, Universal Testing Machine, Vibrating sample Magnetometer, Vector network Analyzer, Vibrating Sample Magnetometer, Brunauer-Emmett Teller surface areas, Zeta sizer, Environmental mode.
Text Book	1. W. Gaddand, D. Brenner, S. Lysherski and G.J. Infrate(Eds.), Handbook of Nano Science, Engg. and Technology, CRC Press, 2002. 2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004. 3. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005. 4. B. D. Cullity, "Elements of X-ray Diffraction", 4th Edition, Addison Wiley, 1978. 5. M. H. Loretto, "Electron Beam Analysis of Materials", Chapman and Hall, 1984. 6. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
Reference book	1. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001
E-resources/Virtual Labs	1. Freely available Lecture Notes by the Eminent Teachers and Instrument Manuals available on www.google.com
EoSE	The duration of the examination shall be six hours wherein the student has to perform any one experiment. The marks distribution shall be the following: 1. One experiment: 50 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester:10

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9145P
Title of the Course	Microwave Electronics Lab
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course (GEC)	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practicum 80+40=120. The 80 hrs for the hands on experiments, observations and record of the data, 20 hours for the experiment, instruments demonstration, lab practices and 20 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*Objectives are to enable the students to understanding of microwave waveguides and transferred electron devices. To distinguish between different types of microwave tubes, their structure and principles of microwave power generation. Understand the basics of Antenna measurements and radiation pattern. An ability to perform microwave measurements.*
Learning outcomes	The students would be able to: • Analyze the characteristics of microwave tubes. • Measure the frequency, wavelength, VSWR and impedance of a microwave signal. • Analyze the radiation pattern characteristics of horn antenna.
Syllabus	
	Experiments: 1. Study the mode characteristics of reflex Klystron and to determine the mode number, transit time, ETR and ETS. 2. Determine the wavelength and frequency of microwaves produced by Klystron source. 3. Determine the wavelength and frequency of microwaves produced by Gunn diode source. 4. Study of the V-I characteristic of a Gunn diode and to measure its power. 5. Determine the dielectric constant of given dielectric material using reflex Klystron.

	6. To study the radiation pattern of given antenna by plotting polar graph and find out 3 dB parameters. 7. To determine the low, medium and high voltage standing wave ratio using Klystron tube. 8. Bragg's diffraction based experiments using microwaves. 9. To study substitution method for the measurement of attenuation and to study variation in attenuation with the frequency. 10. To study square law behaviour of a microwave crystal detector and hence to determine operating range and detection efficiency. Note: Minimum number of experiments to be performed is six
Text Books	1. Lab manuals 2. Microwave Introduction to circuits, Devices and Antennasby M.L. Sisodia& Vijay Laxmi Gupta (New Age International). 3. Microwave Devices and Applications by Dinesh C. Dube (Narosa).
Reference Books	1. Basic Microwave Technique and Laboratory Manual by M.L. Sisodia and G.S.Raghuvanshi (Wiley Eastern Limited). 2. Microwave Engineering by D. M. Pozar (John Wiley & Sons Inc). 3. Microwave Engineering by A. Das and S. K. Das (Tata McGraw-Hill)
Suggested E-Resources/Virtual Lab	1. http://referenceglobe.com/kpsslp/support/upload_videos/microwave-devices-and-circuits-samuel-liao_1588230228.pdf 2. http://alunoeletrica.eng.ufba.br/material/eletromagnetismoaplicado/livros/pozar.pdf
EoSE	The duration of the examination shall be Five hours wherein the student has to perform any one experiment. The marks distribution shall be the following: 1. One experiment: 50 (Formula-8, Figure- 7, Observations-15, Calculations-10, Result-5, Precautions-5 2. Viva Voce: 20 3. 3. Evaluation of the record book of experiments performed in the semester: 10

M.Sc. (Two Year Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY9146P
Title of the Course	Simulations Lab
Qualification Level of the Course	NHEQF Level 6.5
Credit of the course	4
Type of the course (GEC)	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practicum 80+40=120. The 80 hrs for the hands on experiments, observations and record of the data, 20 hours for the experiment, instruments demonstration, lab practices and 20 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics or Chemistry
Co-requisites	None
Objectives of the course	*Simulation can be used to predict the performance of an existing or planned system and to compare alternative solutions for a particular design problem.*
Learning outcomes	• Use MATLAB effectively to analyze and visualize data. • Apply numeric techniques and computer simulations to solve engineering-related problems. • Simulation experiments enhances the students understanding of the theory and the physical concepts covered by the simulation.
Syllabus	

	1. Basic Operations on Matrices. 2. Generation of Various Signals and Sequences (Periodic and Aperiodic), such as Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc. 3. Operations on Signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power 4. Finding the Even and Odd parts of Signal/Sequence and Real and Imaginary parts of Signal 5. Convolution between Signals and sequences 6. Auto Correlation and Cross Correlation between Signals and Sequences 7. Verification of linearity properties of a given continuous /discrete system. 8. Verification of time invariance properties of a given continuous discrete system. 9. Computation of Unit sample, Unit step and Sinusoidal responses of the given LTI system and verifying its physical realiazability and stability properties. 10. Finding the Fourier Transform of a given signal and plotting its magnitude and phase spectrum 11. Locating the Zeros and Poles and plotting the Pole-Zero maps in S- plane and Z- Plane for the given transfer function. 12. Sampling Theorem Verification.
Text Books	1. Basics of matlab programming R. Balaji 2020.
Reference Books	1. Modeling and simulation using MATLAB – Simulink.
	1. https://ece.anits.edu.in/labmanuals/R15%20Sim%20lab%20manual.pdf 2. https://www.mccormick.northwestern.edu/documents/students/undergraduate/introduction-to-matlab.pdf
EoSE	The duration of the examination shall be Five hours wherein the student has to perform any one experiment. The marks distribution shall be the following: 1. One experiment: 50 (Formula-8, Figure- 7, Observations-15, Calculations-10, Result-5, Precautions-5 2. Viva Voce: 20 3. Evaluation of the record book of experiments performed in the semester: 10